

THE FIRST DATA RELEASE FROM SWEETSPOT: 74 SUPERNOVAE IN 36 NIGHTS ON WIYN+WHIRC

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ABSTRACT

SweetSpot is a three-year National Optical Astronomy Observatory (NOAO) Survey program to observe Type Ia supernovae (SNe Ia) in the smooth Hubble flow with the WIYN High-resolution Infrared Camera (WHIRC) on the WIYN 3.5-m telescope. We here present data from the first half of this survey, covering the 2011B–2013B NOAO semesters, and consisting of 493 calibrated images of 74 SNe Ia observed in the rest-frame near-infrared (NIR) from $0.02 < z < 0.09$. Because many observed supernovae require host galaxy subtraction from templates taken in later semesters, this release contains only the 168 NIR (JHK_s) data points for the 33 SNe Ia that do not require host-galaxy subtraction. The sample includes 3 objects with coverage beginning before the epoch of B -band maximum and 26 beginning within 20 days of B -band maximum. We also provide photometric calibration between the WIYN+WHIRC and Two-Micron All Sky Survey (2MASS) systems along with light curves for 786 2MASS stars observed alongside the SNe Ia.

This work is the first in a planned series of three SweetSpot Data Releases. Future releases will include the full set of images from all 3 years of the survey, including host-galaxy reference images and updated data processing and host-galaxy reference subtraction. SweetSpot will provide a well-calibrated sample that will help improve our ability to standardize distance measurements to SNe Ia, examine the intrinsic optical-NIR colors of SNe Ia at different epochs, explore nature of dust in other galaxies, and act as a stepping stone for more distant, potentially space-based surveys.

Keywords: supernova, cosmology

1. INTRODUCTION

Observations of Type Ia supernovae (SNe Ia) indicate that the Universe is accelerating in its expansion (Riess et al. 1998; Perlmutter et al. 1999; Astier et al. 2006; Riess et al. 2007; Wood-Vasey et al. 2007; Kessler et al. 2009; Conley et al. 2011; Betoule et al. 2014; Rest et al. 2014; Scolnic et al. 2014). These results imply that a form of energy coined “dark energy” permeates the universe driving this acceleration or that the theory of general relativity is invalid on cosmological scales.

Learning more about the nature of dark energy requires the study of both nearby and distant supernovae. This range is necessary both for the comparison of luminosity distance at a range of redshift and because studying nearby supernova offers opportunity for much more detailed and higher signal-to-noise ratio studies of the detailed properties of the supernovae and their host environments.

A well-established systematic affecting derived cosmological parameters from SNe Ia is reddening and extinction due to dust (see, for example, Jha et al. 2007; Conley et al. 2007; Wang et al. 2006; Goobar 2008; Hicken et al. 2009; Wang et al. 2009; Folatelli et al. 2010; Foley & Kasen 2011; Chotard et al. 2011; Scolnic et al. 2013). Reddening resulting

from dust is difficult to separate from variations in the intrinsic colors of SNe Ia (Mandel et al. 2016). Near-infrared (NIR) studies offer the opportunity to study SNe Ia with less confusion due to reddening and extinction due to dust than in the restframe optical passbands. For supernovae observed in both the optical and NIR, much more can be learned about the nature of dust through the comparison across wavelengths (e.g., Amanullah et al. 2015).

SNe Ia are also superior distance indicators in the H and K_s (Folatelli et al. 2010; Kattner et al. 2012; Wood-Vasey et al. 2008; Barone-Nugent et al. 2012). This property is explained theoretically by Kasen (2006) whose synthetic light curve calculations confirm that SNe Ia are excellent standard candles in the NIR. These benefits of studying SNe Ia in the NIR motivate the use of large-aperture telescopes to overcome the significant background of the night sky in the NIR to further examine the nature of SNe Ia in this promising wavelength regime.

SweetSpot was an approved 3-year 72-night National Optical Astronomy Observatory (NOAO) survey to image ~ 150 nearby SNe Ia with redshift $z < 0.1$ in the NIR. This work was carried out at the WIYN 3.5-m Observatory¹ at Kitt Peak using the WIYN High Resolution Infrared Camera (WHIRC; Meixner et al. 2010; Smee et al. 2011). The concept of the survey was to build a sample with 3–6 observations per light curve in JH with a nearby subset of ~ 25 observed in JHK_s out to late phases (≥ 30 days) with 6–10 observations per light curve. The goals of the program are to standardize the luminosity of SNe Ia by populating the NIR Hubble diagram in a regime less affected by peculiar motions than previous NIR work, improve our understanding of the intrinsic colors of SNe Ia, and learn more about dust in the host galaxies of SNe Ia.

In this first data release we present 33 SN light curves. These SNe Ia were observed with a median of 6.0 combined observations in J , H and with 4 light curves observed in JHK_s . We begin with a description of the telescope and camera followed by a description of the observations and data in Section 2. The data processing and photometry is discussed in Section 3. In Section 4 we describe the calibration of our system to the Two Micron All-Sky Survey (2MASS; Skrutskie et al. 2006). Section 5 presents and discusses the image and catalog properties and the light curves for 33 SNe Ia. Instructions to access these data are presented in Section 6. Section 7 summarizes the data release and outlines future topics of exploration for SNe Ia in the NIR.

2. OBSERVATIONS

2.1. Description of Telescope and Camera

The WIYN Observatory hosts a 3.5-meter telescope at Kitt Peak National Observatory (KPNO). The Ritchey-Chretien designed telescope has two Nasmyth ports each of which can house one of five instruments currently available, including WHIRC.

WHIRC is a NIR (0.9–2.5 μm) imager with a 3.3' field of view and a 0.1'' pixel scale. The instrument features a 2048x2048 Raytheon Virgo HgCdTe detector. WHIRC is equipped with JHK_s broadband filters and 10 narrow-band filters – for this work we only utilize the broadband filters.²

The WHIRC camera is installed on the WIYN Tip/Tilt module (WTTM) (Claver et al. 2003), which can provide improved seeing in good conditions. In our observations under the SweetSpot program we have found an improvement to the full-width at half-maximum (FWHM) of the image from the tip-tilt correction of 0.1–0.2''. To successfully use WTTM requires a suitable guide star ($R \lesssim 15$ mag) that remains in the WTTM field of view while the dither offsets necessary in NIR observations are executed. For most of the nights in this first data release, WTTM was unavailable due to hardware failures. We were able to use it however on the following nights:³ 2011-10-25, 2011-11-15, 2011-11-21, 2012-11-22, 2013-12-09, 2013-12-13.

2.2. Description of Supernova Sample

The SweetSpot data presented in this work represent the first half of the 3-year survey plus the original pilot data from Weyant et al. (2014). Specifically we publish data from the 2011B, 2012A, 2012B, 2013A, and 2013B semesters. We were awarded 37 effective WIYN nights over 39 distinct calendar nights (there were 4 half nights). We obtained usable on-sky data during 29.5 effective nights across 36 distinct calendar nights (we accounted usable time in half-night chunks). There were 7.5 equivalent nights of lost time due to weather and occasional instrument trouble. Table 1 presents a summary of the number of nights per semester and number of usable nights per semester. Table 2 summarizes the number of supernovae, number of Persson standard stars (Persson et al. 1998), and whether or not

¹ At the time of these observations, the WIYN Observatory was a joint facility of the University of Wisconsin-Madison, Indiana University, Yale University, and the National Optical Astronomy Observatory. <http://www.wiyn.org>

² <http://www.noao.edu/kpno/manuals/whirc/whirc.user.html>

³ All dates in this paper are with respect to the local observatory time, MST, at the beginning of the observing night – even if we didn't start until the second half of the night.

the night was deemed to be photometric.

We selected SNe Ia for follow-up based on IAU Central Bureau for Astronomical Telegrams⁴ (CBET) and The Astronomers Telegram.⁵ To meet our program goals, the criteria for selection were: (1) spectroscopically confirmed as Type Ia; (2) at a phase near B -band maximum; and (3) in our preferred redshift range of $0.02 < z < 0.08$. We used the “Latest Supernovae” website⁶ maintained by David Bishop (Gal-Yam et al. 2013) to track available information about our supernovae, and generated finding charts using data from IRSA⁷. Table 3 presents a complete list of the basic information and the discovery and classification sources for the SNe Ia observed in this data release.

Figure 1 presents the redshift distribution of the SNe Ia observed in DR1. The median redshift of the full sample is 0.034. At this redshift, a peculiar velocity of 300 km/s is only 2.9% of the motion from the Hubble flow of $cz = 10,200$ km/s. This is also higher than the median redshift of the current published data set which is 0.019 (Friedman et al. 2015).

Our goal was to get the first observation in the light curve at least as early as 10–20 days after the time of B -maximum, where we expect SNe Ia to be most standard in H . Due to constraints of when WHIRC was mounted on the telescope, a lack of targets at the beginning of the fall season, and the perpetual vagaries of weather, we were not always able to meet this goal. For the 74 SNe Ia in this data release, (10, 63) have their first observations before (0, 20) days after B -band maximum. For the 33 light curves published in this data release, (3, 26) have their first observations before (0, 20) days after B -band maximum.

Figure 2 shows the distribution of the number of observations of each SN Ia. We have very few K_s observations because of the significantly higher sky background in K_s generally limited us to obtaining K_s observations only for SNe Ia at $z < 0.03$. Figure 3 shows the distribution of observed phase for the observations and light curve points for SNe Ia in DR1. This observed SN Ia phase distribution is largely determined by the the phase distribution of our awarded nights.

2.3. Description of Observations

The major difference between optical CCD versus NIR observations is the significant background from both the sky and detector+telescope system. To separate the effects of spatially and temporally variable sky background, dead and hot pixels, and other instrument and detector artifacts we obtained multiple images of the same field while moving the telescope a small amount between each exposure. This dithering results in imaging the target at several locations on the array.⁸ We have employed three main dither patterns for this survey: a 3x3 grid pattern with 30'' spacing, a 4x4 grid pattern with 20'' spacing and a 5x5 grid pattern with 15'' spacing. Each dither pattern travels over a 1' square centered about the target coordinates of equal exposure time. Thus our co-added image stack for an observation typically covers $4' \times 4'$ from a set of raw $3.3' \times 3.3'$ “raw” dithers. Figure 4 shows the total exposure time maps characteristic of each dither sequence. Dither patterns were repeated or different dither patterns were combined to increase the total exposure time.

⁴ <http://www.cbat.eps.harvard.edu/cbet/RecentCBETs.html>

⁵ <http://www.astronomerstelegram.org>

⁶ <http://www.rochesterastronomy.org/supernova.html>

⁷ <http://irsa.ipac.caltech.edu/applications/FinderChart/>

⁸ http://www.noao.edu/kpno/manuals/whirc/WHIRC_Datared_090824.pdf

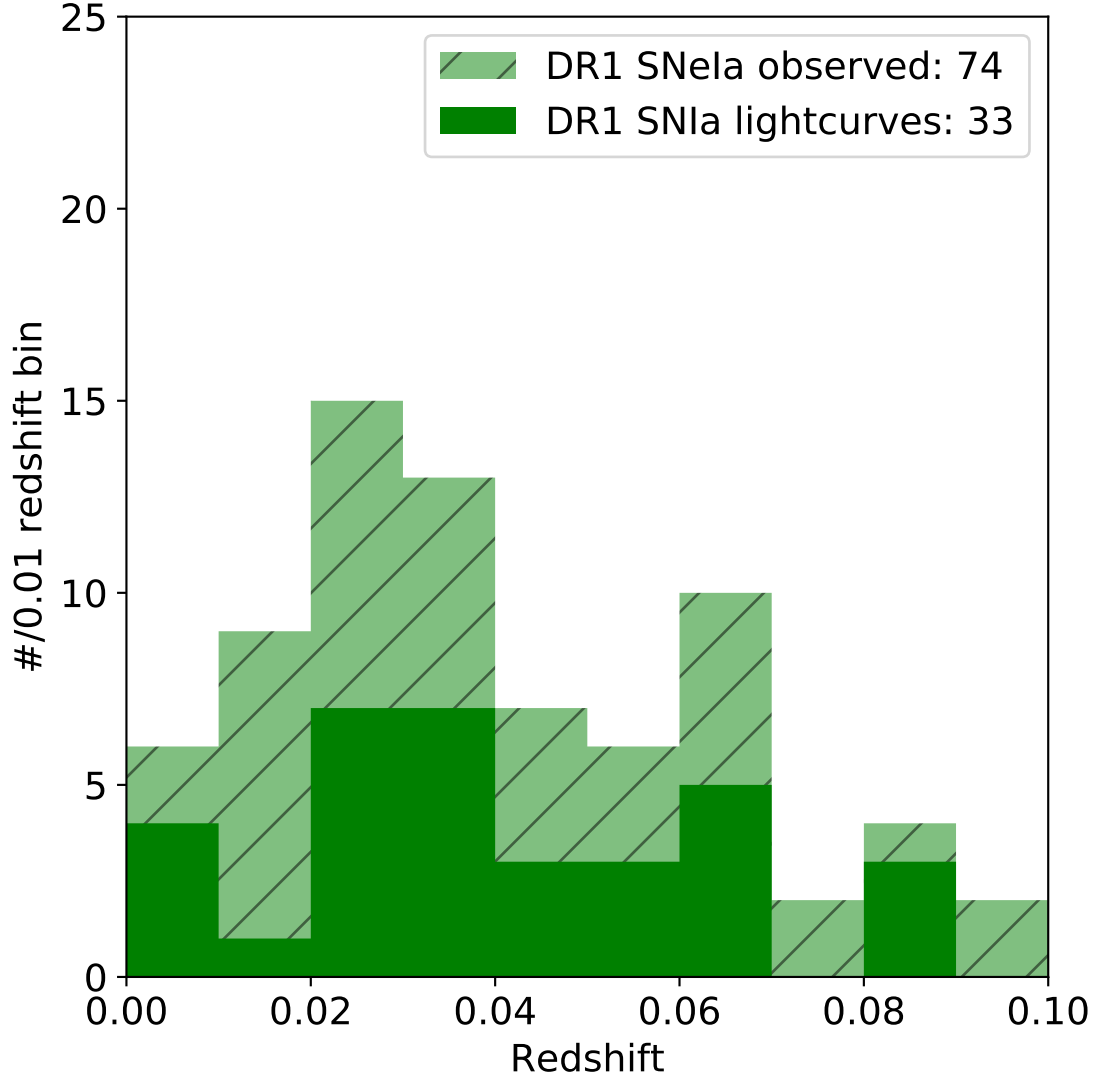


Figure 1. Distribution in redshift of the supernova presented here. The SweetSpot survey is significantly increasing the number of SNe Ia above $z > 0.03$ with observations in the NIR where measurements of the distance-redshift relation are less affected by peculiar velocities. 74 supernovae were observed in DR1 (hatched light green). 33 have light curves in DR1 (solid green). Green was chosen because all supernovae were observed at least in H-band – which will be represented by green throughout the rest of this paper.

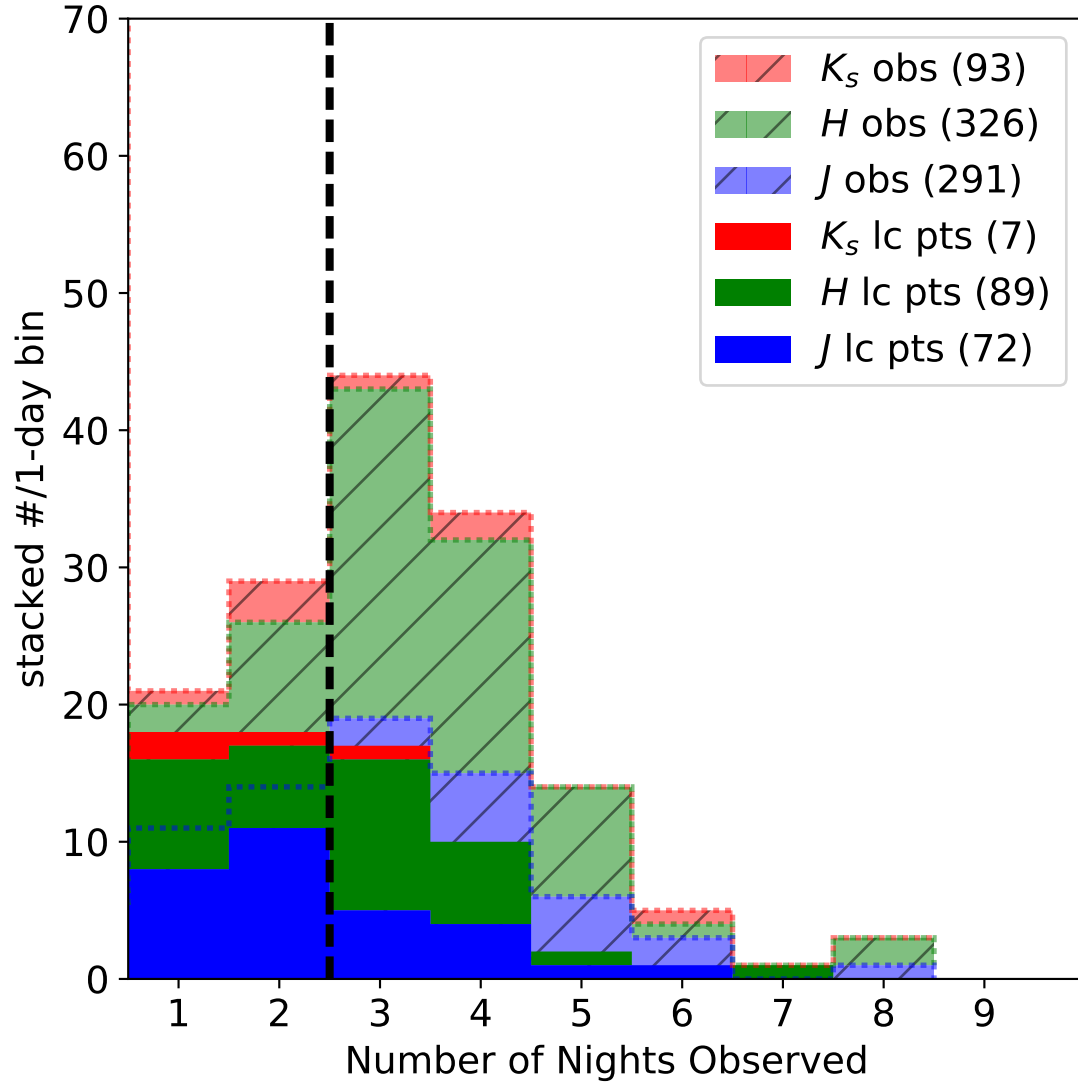


Figure 2. Number of observations for each supernovae (dotted) and filter. Number of points in each light curve being presented in this paper (solid). Stacked histograms for each of J (blue), H (green), and K_s (red).

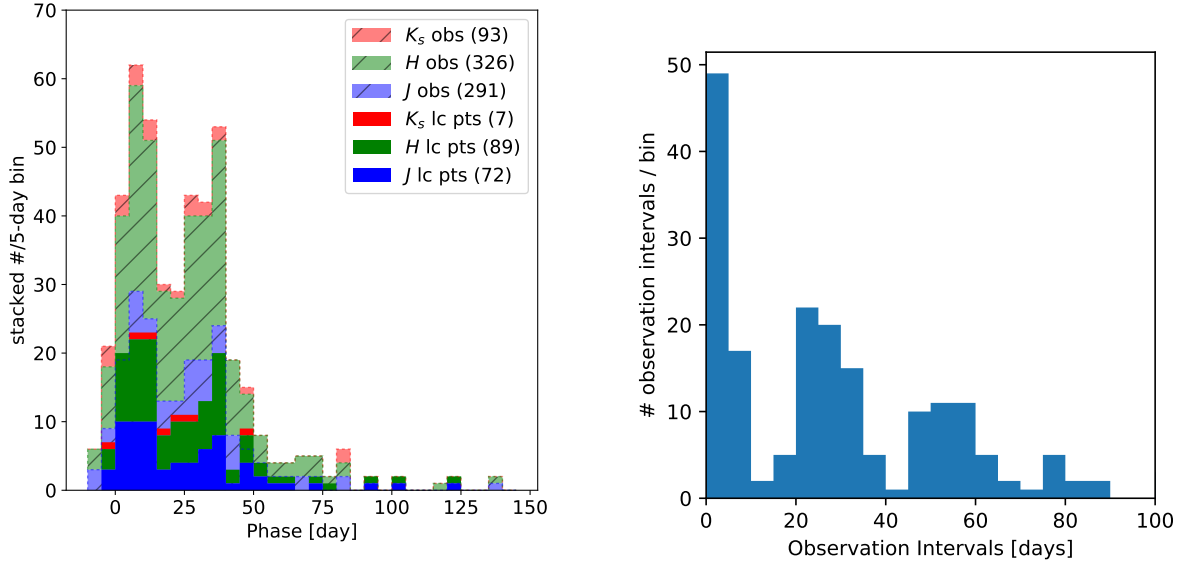


Figure 3. (left) Phase of 493 observations (dotted) and 168 light curve points (solid) stacked for each of J (blue), H (green), and K_s (red). The two-peaked structure is primarily due to the scheduling of our observed nights in grey and bright time. (right) The distribution of intervals between observations – truncate at 100 days for easy of comparison because we follow very few supernovae past 100 days.

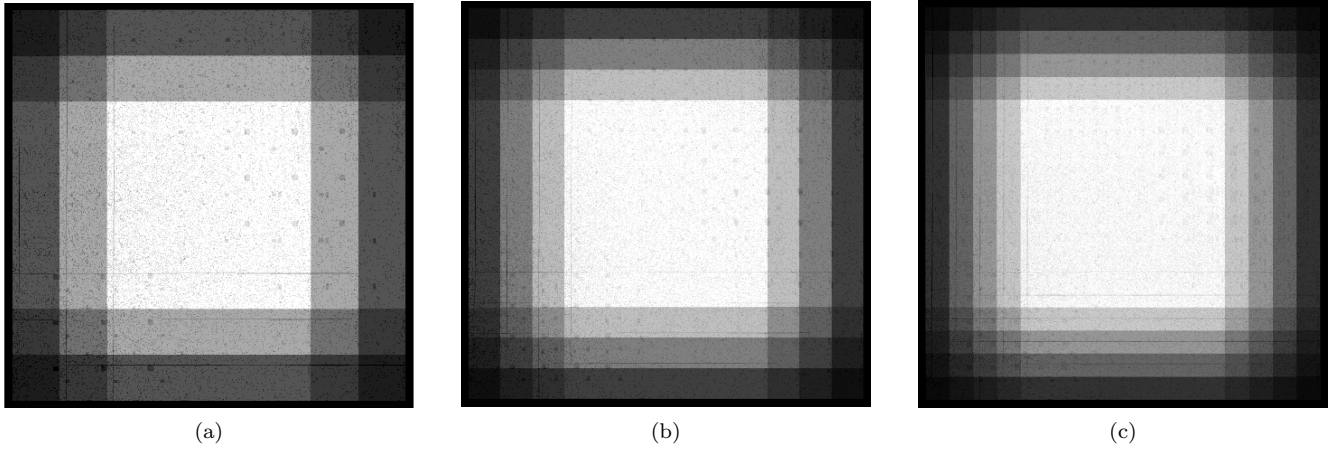


Figure 4. Exposure maps of typical WIYN+WHIRC stacked observation sequences. Our program employs dither patterns of: (a) 3x3 grid with 30'' spacing; (b) 4x4 grid with 20'' spacing; and (c) 5x5 grid with 15'' spacing. The displayed steps from black to white in each image above are (0, 1, 2, 3); (0, 1, 2, 3, 4); and (0, 1, 2, 3, 4, 5) exposures. Exposure times at each individual pointing were 60 s for supernova targets and 10 s for Persson standard stars. A combination of dither patterns were used to achieve different total exposure times. E.g., for a 41-minute effective exposure time we would observe a 4x4 dither sequence followed by a 5x5 dither sequence.

We also obtain dome flat calibration images on each night in (J, H, K_s) consisting of eleven 5-s dome flats with the “high” flat lamp on and eleven 5-s flats with the lamp off. The lamp settings evolved slightly during the DR1 observing semesters. In 2011B–2012A, we used settings of (600, 415, 380) respectively for $(J, H, \text{and } K_s)$, while in 2012B, 2013A, and most of 2013B we used settings of (650, 450, 380). These numbers are proportional to the voltage applied to the lamps. The WHIRC users manual updated the flat lamp information in 2013 October based on the re-coating done in the summer 2013 and we switched to the newly recommend values of (600, 425, 380) on 2013-11-16. Specifically, these lamp settings are the recommended flat-field lamp settings for the Fowler-1 readout mode (see Table 4 of the WHIRC user manual⁹) and yield 10,000–12,000 counts in the central region of each raw dome flat.

For a typical SN Ia target observation, we execute a dither pattern with a 60-s exposure at each pointing. Our observations are almost always executed in JH order, but with priority given to H if there is only time for one filter. For nearby targets ($z < 0.02$) we also observe in K_s . Beginning in the middle of the 2012B semester, we started observing photometric standard stars from Persson et al. (1998) in JHK_s . We list the Persson standards we observed in Table 4. For these Persson standard observations, we executed a $3\times 3\times 30''$ dither pattern with a 10-s exposure at each pointing in JHK_s .

3. PROCESSING OF THE IMAGE DATA

3.1. Instrument Signature Removal and Co-addition

The WHIRC images were processed using a Pyraf¹⁰-based analysis program written by Ralf Kotulla.¹¹

In 2012 we forked at revision 180 and made modifications to activate different modules and procedures for object masking and WCS registration.

For each of the nights of data in this data release we carried out the following steps:

1. **Data Transfer:** To ensure repeatability and consistency of our analysis, we downloaded the raw images from the NOAO Science Archive server by retrieving images matching (PI, Program, telescope+instrument) = (Wood-Vasey, 2012B-0500, WIYN+WHIRC) for the desired observing date. We downloaded the data using `lftp`¹² which allowed for parallel transfers of up to 16 simultaneous streams. Typical download times for a typical night’s 2.1 GB of compressed data were ~ 10 minutes (3.5 MB/s).
2. **Uncompression:** The raw images are stored on and transferred from the NOAO Science Archive as Rice-tile-compressed¹³ FITS¹⁴ files (Wells et al. 1981; Hanisch et al. 2001; Pence et al. 2010). We use `funpack`¹⁵ to uncompress these files. We re-name the files to their original filenames as when observed based on the DTACQNAM header keyword; this re-naming makes it easier to compare against the observer’s log files from the night and to do some name-based filtering.

We also correct `IMGTYPE` headers that due to observer error often get written as “acquire” or otherwise not as “object” for science observations. In addition there are occasional errors in the data archive headers for `DTACQNAM` and `DTITLE` that we rewrite to preserve standard FITS compliance.

To ensure repeatability all corrections that change header information or mark certain types or names of files as bad are stored as version-controlled pre-analysis scripts in our pipeline.

3. **Nonlinearity Correction:** We start using the functions in `reduce.py` with this step. We first apply the non-linearity correction for the WHIRC detector using `reduce.nonlinearity`. Applying non-linearity first is appropriate because the non-linearity applies at the raw count values. The non-linearity correction applied is a 3rd-order polynomial in the original data values (in our Fowler-1 readout mode):

$$\text{data}_{\text{corrected}} = a \times \text{data}_{\text{raw}} + b \times \text{data}_{\text{raw}}^2 + c \times \text{data}_{\text{raw}}^3 \quad (1)$$

using the correction coefficients listed in the WHIRC data reduction manual (a, b, c) = $(1, 1.29 \times 10^{-7}, 2.506 \times 10^{-11})$.

⁹ <http://www.noao.edu/kpno/manuals/whirc/whirc.user.html>

¹⁰ http://www.stsci.edu/institute/software_hardware/pyraf/; v2.0 revision 1795

¹¹ <http://pubsvn.galev.org>

¹² http://archive.noao.edu/app_ext/contrib/ftp/lftp.readme.txt

¹³ <http://fits.gsfc.nasa.gov/registry/tilecompression.html>

¹⁴ <http://fits.gsfc.nasa.gov/>

¹⁵ <http://heasarc.nasa.gov/fitsio/fpack/>; Version 1.1.0 (August 2008)

4. **Dome-flat construction:** We prepare flats based on the dome-lamp observations and a known template for the WIYN+WHIRC pupil¹⁶ using `reduce.makeflats`. Each afternoon a set of 5-s flats are taken in each of (J,H,Ks) with the WIYN “high” lamp on the setting described in Section 2. A matching set of 5-s flats with the lamps off is taken in the same several-minute sequence. By subtracting the median co-addition of the lamp-off flats from the median co-addition of the lamp-on flats, we obtained combined images that represent only the variation in effective sensitivity of the system from the flat-field screen through to the detector, and removed the effects of thermal radiation from the optics or telescope. We take this master dome flat and then remove the effect of the pupil ghost based on the pupil template to create a FITS file that contains the response function for each filter *JHK_s*. As part of the flat-generation step, we also generate a bad-pixel mask based on a stored *bad_pixels.reg* region file with additions from the detected hot and cold pixels in the flat, defined as those pixels which differ by 5σ from the local median value in a 5×5 square kernel.

Generation of an image cleaned and corrected for the sky background is a two-step process. We first estimate a rough sky image to be able to remove enough sky background from the image to identify astrophysical sources. We then apply this master sky flat to each individual raw image. After masking out the astrophysical sources, we re-estimate a master sky image and use this cleaner sky image to perform the final sky correction for the individual images.

5. **Sky-flat construction:**

The raw image headers are used to generate a *marksky.log* file that lists the raw image name, object, and if the file was a sky frame, object frame, or both. This list is the place where we later manually mark bad individual images.

The routine `reduce.makeskies` reads this list and sorts the images into lists for each field+filter. An initial estimate of the sky in each raw frame is made based on the median of 3-sigma-clipped image. The raw frame is then *divided* by this sky background to normalize each image to a fiducial sky value of 1. These images are then median-coadded using Pyraf’s `images.immatch.imcombine` for each field+filter for a night to generate a master sky image for that field+filter. This co-addition is done in detector space; thus the dithered images median out the astrophysical sources and leave the (presumed constant) sky background.

6. **Sky correction to all individual frames:** For each raw frame, the master sky image for each field+filter is applied to each image from the non-linear correction stage. The master sky image is multiplied by the estimated sky background from the previous step for the given raw frame, and then subtracted from that frame to yield a sky-subtracted image. This sky-subtracted image is then divided by the response file calculated during the flat fielding step above. A bad-pixel mask for the particular image is generated based on the template bad-pixel mask. This processing is done using `reduce.subtractsky_flatfield`

We do not attempt to remove the Newton’s ring pattern from Paschen- β night sky lines. Both the intensity and phase of this pattern varies due to the varying sky conditions. While visible to the eye in some of the data when displayed at a `zscale` stretch, the effect on the photometry is minimal (< 0.001 mag) as the contribution of the ring pattern is small in relation to the overall sky variation.

7. **Refine sky subtraction:** The flattened images are processed using Source Extractor (Bertin & Arnouts 1996) in `SEGMENTATION` mode to identify objects and to generate a mask file with every pixel that is ascribed to an object masked. The segmentation mask is grown around the marked bad images updated by applying 1-pixel Gaussian kernel to the segment mask (where masked pixels have a value of 1) and masking all pixels in the convolved mask that have a value greater than 0.005. For an isolated bad pixel, this masks the 21 pixels in a 5-pixel diameter discretized circle around the bad pixel. Using `reduce.refine_skysubtraction`, the background is re-estimated from this masked image, and a new set of normalized sky frames are created. This set is median combined into a new sky frame for each field+filter set.

The final flat-fielded raw image is generated using this new sky frame in the same sky subtraction and flat-fielding process as above.

8. **Apply geometric distortion correction:** The known geometric distortion of WIYN+WHIRC is corrected using `reduce.geotran` to run `iraf.images.immatch.geotran` with a bicubic spline interpolation, to generate

¹⁶ <http://www.noao.edu/kpno/manuals/whirc/whircpupil.fits.gz>

undistorted individual images. While not the theoretically optimal solution for maintaining information and minimizing covariance when coadding images, it is convenient to apply this transformation before shifting and combining the images for stacking.

The distortion solutions were based on the WHIRC online data reduction manual.¹⁷ Specifically the files¹⁸ used were those prepared by NOAO as of 2009-03-05.

9. **Alignment of raw images to common reference:** The relative alignment of the set of images from a given observing sequence are now aligned to the middle image of the dither sequence. The dither patterns used in this program are constructed so that the image in the middle of the sequence is also the image in the middle of the spatial pattern. **Source Extractor** is run on each raw image and the alignment is by matching the (x, y) positions between the catalog for each raw image and the catalog of the central image. This offset is recorded by updating the WCS information in each raw image (stored as a CD matrix) to be that of the central raw image plus the calculated transformation. This is not necessarily a correct absolute WCS, merely a way of storing the transformation to the reference image. The images are assumed to have no change in rotation or plate scale between them. The specific (x, y) offsets and uncertainties (in pixels) are also stored in keyword headers **ALIDX**, **ALIDXERR**, **ALIDY**, and **ALIDYERR**. The number of stars used to align the raw to the central reference raw is stored in **ALINSTAR**. The images are written out to disk with header values noting the relative shifts, but they have not been actually moved.
10. **Stacking: combination of raw images into coadded stack:** First the images are graded on the alignment offset uncertainties (**ALIDXERR**, **ALIDYERR**) from the previous step. Any image with an uncertainty in the x or y offset of more than 10 pixels is rejected from being incorporated in the stack. This quality cut rejected 11% (1,504 out of 13,339) of the raw images.
The actual stacking begins with using Pyraf's `iraf.images.immatch.wregister` to shift the raw images, with no interpolation, to a common pixel grid based on the results of the previous step that calculated the alignment. The shifted images are then median-combined using Pyraf's `iraf.images.immatch.imcombine` and an exposure map is generated to record the different effective exposure times of each pixel. These exposure maps provide the information to properly track the pixel-by-pixel variance of the co-added stacks.
11. **WCS and preliminary photometric calibration:** To determine the WCS calibration and estimated photometric calibration for these co-added stacks, `reduce.calibrate` runs **Source Extractor** on the co-added stacks. The resulting catalog is compared against the 2MASS catalog to generate the astrometric calibration and to provide an estimate of the photometric calibration. While the photometric calibration from this step is not used in the final calibration (see Section 4), a failure to generate a reasonable rough photometric calibration in this step is used as an indicator that future photometric calibration will not be successful.

In Weyant et al. (2014) we used scripted but manually-run IRAF-based analysis following the steps outlined in the WHIRC Data Reduction manual. These two approaches deal with the same basic issues of image reduction, but differ in some of the specifics. The image reductions we present here supersede those of Weyant et al. (2014) as do the photometric catalogs and light curves described in the following sections.

3.2. Photometry

We use aperture photometry on the stacked images to measure the instrumental magnitudes of the SN Ia and stars in the field. This photometry relies on an accurate WCS solution to locate the 2MASS stars and the SN Ia in the field. While all successfully generated stacks are provided as part of this data release, we applied the following additional quality cuts to those used in photometric light curves. First, a visual inspection was performed to determine if the stacked images were combined properly and to determine if the WCS solution is reasonable. The inspection of each stacked image is detailed in Table 5.

The orientation and scale of the detector are well known. Thus manually-generated WCS solutions were generated for the 66 images with visually good stacks but which failed the automatic WCS determination by identification of a reference star x , y and RA, Dec. Through this process we noted that the two images of SN 2012gm from 2011-11-22

¹⁷ <http://www.noao.edu/kpno/manuals/whirc/datared.html>

¹⁸ <http://www.noao.edu/kpno/manuals/whirc/whirc.distort.j.db>, <http://www.noao.edu/kpno/manuals/whirc/whirc.distort.h.db>, <http://www.noao.edu/kpno/manuals/whirc/whirc.distort.k.db>

are offset 4' from the intended pointing and thus do not include the supernova. Any stack with a `ZP_ERROR` outside the range of (0, 1] mag was rejected from further photometric processing.

These co-added images with bad astrometric or photometric solutions are included in this data release for completeness, but no corresponding catalogs or supernova light curve points are generated from these problematic co-additions.

We perform aperture photometry on stars in the field which are listed in the 2MASS point-source catalog as downloaded from the VizieR catalog service¹⁹. We require that the 2MASS catalog entries for these stars have a $SNR > 5$ in each of JHK_s and that the 2MASS catalog flag values indicate that the star is in not blended or affected by known artifacts, e.g., contamination from a bright nearby star or extended source, diffraction spike, etc. This is our operational definition of 2MASS “star” for the purposes of this present section.

Our median effective FWHM in our WIYN images is 0.7'' and we are able to resolve some 2MASS “star”s as being extended or into multiple objects (the 2MASS typical FWHM was 2.5-3''). We perform an additional level of inspection of these objects when defining the standard stars that define our WIYN+WHIRC calibrators for each field – see Section 4.4 for details. However, we provide aperture photometry for the full set of 2MASS “star”s in our fields.

We observed 6 Persson standard stars as part of our observations (Table 4). We updated the positions listed in the Persson catalog for these stars to the (RA, Dec) listed in the 2MASS catalog.

The location of the SN Ia was originally taken from the reported position of the SN Ia from its original ATTEL or CBET (see Table 3). This position was then translated to a region file and visually inspected in `ds9`.²⁰ If the position was discrepant from the location of the SN in our WIYN+WHIRC postage stamps, it was updated based on visual selection of the (RA, Dec) position of the SN Ia in the highest SNR image available (either in J or H). Many (48/74) of the SN positions were shifted in this way by $< 1''$. We attribute these shifts to a combination of the uncertainties in real-time detection systems, and the often larger effective seeing of SN search programs (1–2'') particular compared to the often excellent seeing at WIYN+WHIRC (median 0.7''). The list of 2MASS (RA, Dec) and the (updated) position of the SN Ia were then used as the centers for aperture photometry. It is these updated positions that we report as the SN in Table 3.

We updated the positions of the 2MASS stars (including the Persson standards) using the Goddard Space Flight Center (GSFC) IDL²¹ Astronomy User’s Library routine `gcntrd`.²² This re-centering procedure accounts for (a) uncertainties in the 2MASS positions that are better determined in our WHIRC images; and (b) astrometric imprecision in our WHIRC image WCS solutions to the 2MASS frame (this imprecision comes from both uncertainties in position, and from the limited number of stars in the limited WHIRC field of view in the sparser fields); (c) proper motions of stars in the field since the 2MASS observations that were not sufficiently well-determined in the 2MASS catalog. Because we were using this re-centroiding to account for multiple factors, we adapted the `gcntrd` routine to allow for larger pixel shifts to accommodate the high-resolution, oversampled WHIRC images. We did not use this re-centering for the SN positions as we did not want to be susceptible to variability in position as the SN fades. The 2MASS stars in our WIYN+WHIRC images are all bright enough that they have plenty of S/N to spare for re-centering.

We measure the FWHM from the image by fitting a 2D Gaussian to each 2MASS star in the image using Eric Deutsch’s IDL routine `starfit.pro`.²³ We then choose the median FWHM from this set of stars as the best estimate for the FWHM of the image. We performed aperture photometry at an array of radii – [2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 25, 30, 40] pixels – for later uses in computing aperture corrections and selecting the optimal S/N radius for the final quoted photometry. The background was estimated from a sky annulus from 41–50 pixels (i.e., 0.1''–1.0'' beyond the maximum adopted aperture size).

We used these aperture and sky annulus values to measure the detected counts of objects in the field using the GSFC IDL routine `aper`.

The stacks are computed in terms of the integration time of the raw dither in the sequence. This exposure time is generally 60 s for SN images and 10 s for Persson standard star fields. We record the instrumental magnitudes in standardized counts-per-second convention.

$$m_{\text{inst},f} = -2.5 \log_{10} \frac{\text{ADU}}{\text{exptime}_{\text{raw}}} \quad (2)$$

¹⁹ <http://vizier.u-strasbg.fr/>

²⁰ <http://ds9.si.edu>

²¹ IDL is a product of Harris Geospatial Solutions (formerly Exelis; ITT Visual Information Solutions; and Research Systems Inc.): <http://www.harrisgeospatial.com/ProductsandSolutions/GeospatialProducts/IDL.aspx>

²² W. Landsman, 2004–2009. GSFC IDL Astron library. <http://idlastro.gsfc.nasa.gov/>

²³ <http://www.astro.washington.edu/docs/idl/htmlhelp/library03.html#STARFIT>

4. CALIBRATION

We here describe the analysis part of our processing which starts with the raw instrumental photometric catalogs derived in the previous section. We have split these Sections 3 and 4 thusly, as all of the steps in this section can be reproduced from the photometric catalogs without need to refer to the imaging data.

4.1. Definition of WHIRC Natural System

We base our WIYN+WHIRC natural system on the 2MASS system at a given set of characteristic colors. We then calculate fit coefficients for color terms and airmass terms. The color term is a description of the difference between the WIYN+WHIRC and 2MASS systems, while the airmass term is a property of the atmosphere above KPNO.

Specifically, we use the following standard transformation between the measured instrumental magnitudes and the 2MASS system as a function of the airmass, X , and 2MASS color, $\Delta_{m_1, m_2}^{2MASS}$, using the following equation

$$m_f^{2MASS} = m_{inst, f}^{WHIRC} + zpt_f - k_f (X - 1) + c_f (\Delta_{m_1, m_2}^{2MASS} - \Delta_{ref}^{2MASS}) \quad (3)$$

where f designates the filter; zpt is the per-second zeropoint of the WIYN+WHIRC system in filter f ; k_f is the airmass coefficient²⁴ for filter f ; and c_f is the color coefficient.

We define the reference point for translations between the WIYN+WHIRC natural system and the 2MASS system at these reference 2MASS colors: $\Delta_{ref}^{2MASS} = m_J^{2MASS} - m_H^{2MASS} = 0.5$ mag for J and H and $\Delta_{ref}^{2MASS} = m_H^{2MASS} - m_{K_s}^{2MASS} = 0.5$ mag for K_s . These reference colors are selected as being characteristic of the stellar populations observed. They also conveniently roughly describe the NIR colors of a SNe Ia after maximum light. We obtain m_f^{2MASS} and $\Delta_{m_1, m_2}^{2MASS}$ from the 2MASS Point-Source Catalog (Cutri et al. 2011). We determine X from the metadata for the observation, and measure $m_{inst, f}^{WHIRC}$ from our WIYN+WHIRC images (as described in Section 3). Our calibration process then becomes fitting for the calibration coefficients: zpt_f , k_f , and c_f .

We base our absolute photometric calibration using 2MASS stars observed on photometric nights. Photometric nights were defined as those in which we had no contamination from clouds as judged by the observer. Table 2 lists those nights along with the number of Persson star observations each night.

We calibrate using 2MASS stars in the magnitude ranges of $10 < H < 15.5$ mag, $10 < J < 15.8$ mag, and $10 < K_s < 14.3$ mag. The bright limit avoids stars that will likely be saturated in our WIYN+WHIRC images, while the faint limit loosely corresponds to requiring a SNR > 10 for the 2MASS measurements of the stars. To minimize sensitivity to variations in the PSF across different images, we calculate an aperture correction to standardize the effective aperture at 40 pixels ($4''$).

4.2. WTTM Refurbishment

In 2013 February, the WIYN engineering crew removed the WTTM module from the telescope. The WTTM instrument and the 4 mirrors were inspected. The surface of the tip/tilt mirror was found to be significantly degraded and the other three mirrors (M1, M2, and M3) were dusty. All the WTTM mirrors were cleaned with CO₂ during this 2013 February servicing. Motivated by this inspection, and because WHIRC is the only instrument now mounted on WTTM, NOAO decided to re-coat the WTTM mirror with gold for improved NIR performance (it previously had a silver-based coating more appropriate for its previous use with the Mini-Mosaic Imager²⁵). Unfortunately, the M2 mirror was destroyed in shipment and the M1 and M3 mirrors suffered minor damage. The tip/tilt mirror was undamaged. The M1 and M3 mirrors were repolished. The M2 mirror was replaced with an engineering spare which was polished to match the figure of the original M2 mirror. The mirrors were then re-coated. The replaced mirror changed the effective figure of the WTTM system, making the focus a bit more sensitive. A more extensive record of updates to WHIRC is available at the NOAO WHIRC website.²⁶

4.3. Calibration of Data Before and After WTTM Refurbishment

The cleaning and re-coating of the WTTM mirrors led to a notable, apparently grey, improvement in system throughput (0.7 mag in J , 0.7 mag in H , and 0.5 mag in K_s ; see below). For the purposes of calibration, we therefore split the data into two samples: 2011B–2013A (before the mirrors were replaced, “old”) and 2013B (after, “new”). Assuming the re-coating was grey in its increase in sensitivity, the color term should not change. According to its

²⁴ Our chosen sign convention means that k should be positive. The opposite convention is also common in the literature, including in Weyant et al. (2014).

²⁵ <https://www.noao.edu/kpno/manuals/minimo/minimo.html>

²⁶ <http://www.noao.edu/kpno/manuals/whirc/hotnews.html>

physical meaning k_f should not have changed (to first order) across the mirror replacement and re-coating; any change in k_f from a change in the color response would be second order. Given that we do not fit for a color \times airmass cross term originally, we similarly do not fit for a change in such a term. We verified that the chisq surfaces are consistent between the “old” and “new” samples for the values of k_f and c_f . We thus fit a constant k_f , c_f across 2011B–2013A and 2013B, but separate $\text{zpt}_f^{\text{old}}$ and $\text{zpt}_f^{\text{new}}$ coefficients.

To provide a clean measurement of k_f from bright stars, we use our repeated observations of Persson standard stars: P161-D, P212-C, P330-E, P525-E, S791-C, and S840-F. These have the advantage of being very high signal-to-noise measurements ($100 < \text{SNR} < 1000$, median 500) and confirmed stars. Our observations of these standards span an airmass range of 1.001–1.930. The Persson standards we observed cover a color range from $0.15 < J - H < 0.70$ mag.

Holding k_f constant, we use the comparison of WHIRC instrumental magnitudes and 2MASS catalog values for 2MASS stars from the photometric nights to jointly solve for $\text{zpt}_f^{\text{old}}$, $\text{zpt}_f^{\text{new}}$, and c_f . These derived photometry coefficients are given in Table 6. Figure 5 shows the Persson stars used to derive the airmass coefficient and the 2MASS stars used to derive the color terms and per-second zeropoint of the system. The resulting per-image zpt values are showing in Figure 6, where the distinction between the “old” and “new” set is quite evident.

Figure 7 illustrates the WHIRC filter functions²⁷ vs. the 2MASS system (from the SNooPy reference file; which is originally from the 2MASS Explanatory Supplement²⁸). While we did not quantitatively use the WHIRC filter functions in calibrating our system, the positive color terms we find with respect to the 2MASS system are consistent with the redder extents of the WHIRC filters.

Section 4.4 details how the photometric coefficients for the WIYN+WHIRC system are used to derive the WIYN natural system.

4.4. Reference star for each field

The zeropoint of the WIYN+WHIRC system was calibrated to that of 2MASS because of the all-sky coverage of 2MASS and the availability of 2MASS objects in each of our SN fields. A reference star is selected in each field that was observed on a photometric night (see Table 2). We calculate the difference between the WHIRC instrumental magnitude and the 2MASS catalog magnitude in H (i.e., the “zeropoint” uncorrected for airmass or color). To make a robust selection of the comparison star, we select a star whose “zeropoint” is consistent with the median of this “zeropoint” distribution. We also require that this star is within $2'$ of the SN Ia, and has an H -band magnitude between 10 and 15.5 mag.

The increased resolution of WIYN+WHIRC (H -band median FWHM $0.87''$) over 2MASS (H -band median FWHM $2.8''$) allows for the resolution of a number of 2MASS point sources into resolved galaxies or multiple point sources. While we do not explicitly present a star-galaxy catalog as part of this work, the catalogs we present here do provide measured FWHM values for each object and characteristic FWHM values for each image. For the standard stars as originally selected below, we inspected postage stamps for all of our WIYN+WHIRC images of each star visually and identified that 8 of these 2MASS point sources were either extended objects or consisted of multiple objects: 7 were resolved into galaxies and 1 into a “visual” binary. Alternate 2MASS stars that were still point sources in the WIYN+WHIRC images, still otherwise satisfying the above criteria, were then selected by hand for these 8 fields.

The appropriate zeropoint-per-second, k_f , and c_f coefficients from Table 6 were applied to the observed WHIRC instrumental magnitude of the star and its observed airmass to generate the defining WHIRC reference magnitude for each field’s reference star.

$$m_{\text{cal},f}^{\text{WHIRC}} = m_{\text{inst},f}^{\text{WHIRC}} + \text{zpt}_f - k_f (X - 1) \quad (4)$$

Eight supernovae: SN 2011io, PTF11qzq, PTF12ikt, SN 2012go, SNhunt175, SN 2013bq, CSS130218:092354+385837, and SN 2013cb were not observed on a photometric night. For these objects, the first night that the object was observed on was chosen as the reference night.

The full list of reference stars is given in Table 7 and provided in *WHIRC_standard_star_catalog.fits*. The calibrated standard stars in the WHIRC natural system were generated using Equation 3 and the results from Table 6.

The WHIRC standard star for each field is used to find the zeropoint for each stacked image as follows

$$\text{zpt}_{f,i} = m_{\text{cal},f}^{\text{WHIRC}} - m_{\text{inst},f,i}^{\text{WHIRC}} \quad (5)$$

where the i subscript indexes over the stacked images and $m_{\text{cal}}^{\text{WHIRC}}$ is the single WHIRC standard star for that

²⁷ <http://www.noao.edu/kpno/manuals/whirc/filters.html>

²⁸ http://www.ipac.caltech.edu/2mass/releases/allsky/doc/sec6_4a.html#rsr

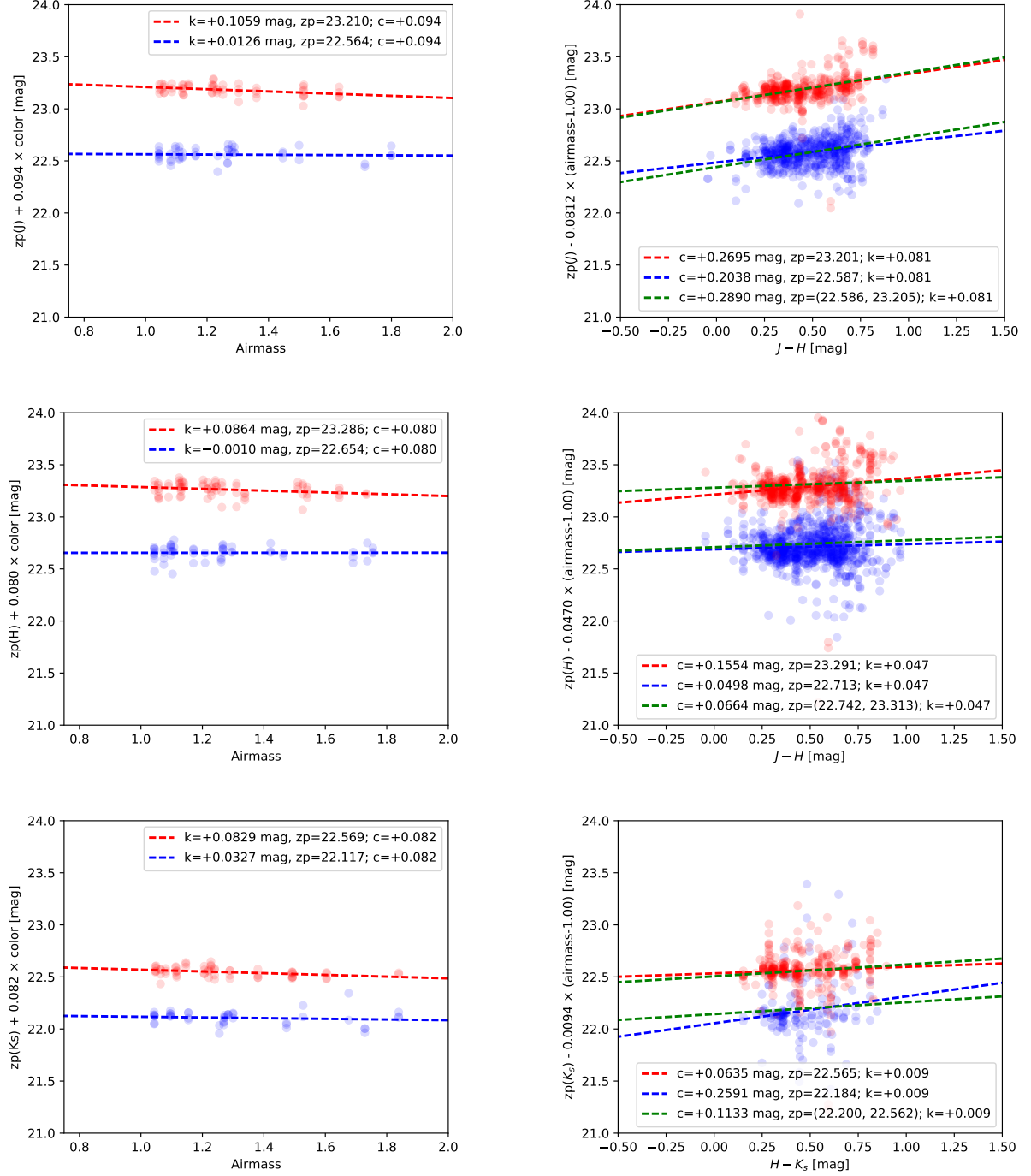


Figure 5. The difference in 2MASS magnitude and WHIRC instrumental magnitude for the Persson standard stars for airmass corrected for color (left column), and for the 2MASS stars for color and zeropoint using the fixed Persson-derived airmass coefficient (right column). The rows are for J , H , and K_s . Results prior to the mirror re-coating and replacement (2011B-2013A) are in blue, results from after (i.e., 2013B) are in red, and results from a joint fit to k_f , c_f , zpt_f^{old} , and zpt_f^{new} are in green. For illustration, the green dashed lines are the values for the old (lower) and new (higher) zeropoints vs. airmass coefficient when the color coefficient is fixed at $c_f = 0$. We use the joint-fit values in our photometric calibration.

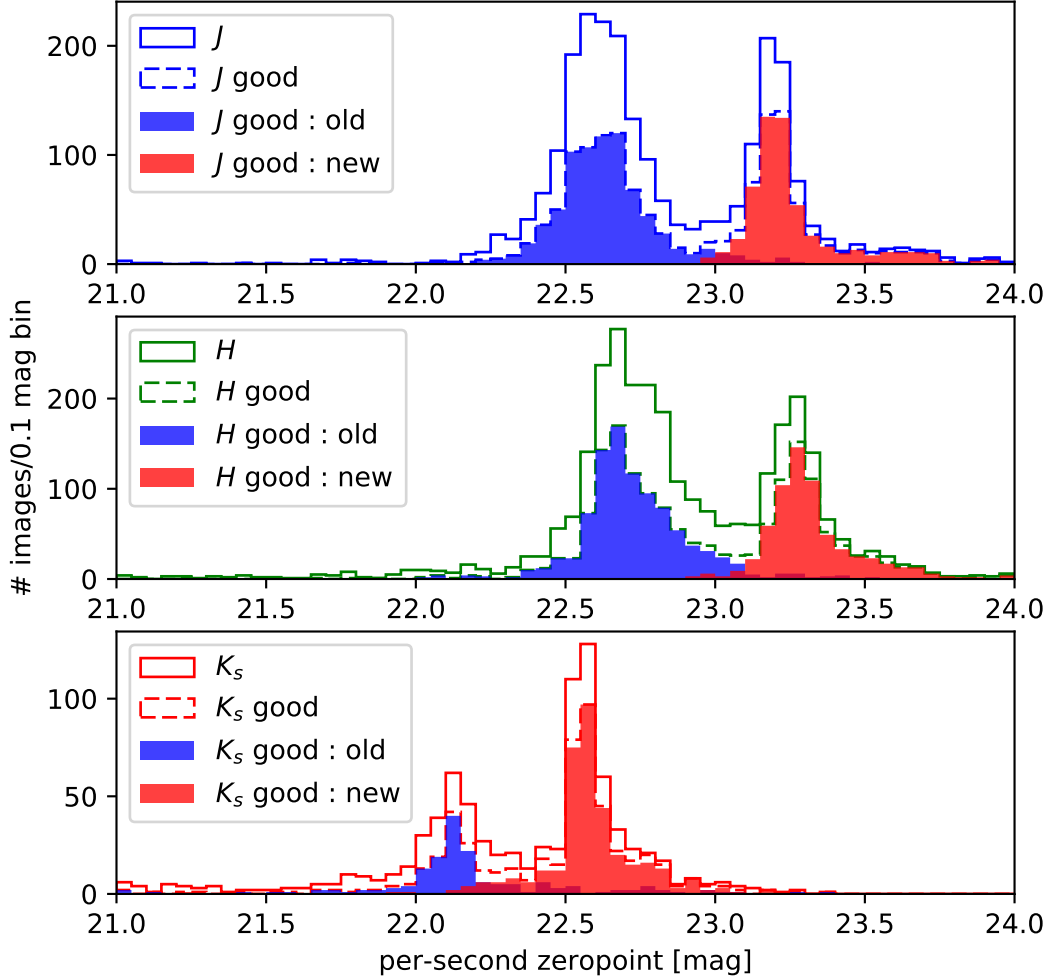


Figure 6. Comparison of the WIYN+WHIRC per-second zeropoint from (2011B–2013A; blue) and (2013B; red) for (J , H , K_s) (top, center, bottom). Solid lines show the distribution for all data combining both eras. Dashed lines show the distribution for all photometric (“good”) data combining both eras. Color-coding of these solid and dashed lines follows the filters (blue, green, red) for (J , H , K_s). Solid filled histograms show the results for “good” data from each era. Color-coding of these histograms displays the era (filled blue: old, filled red: new). Re-coating the optics resulted in a clear improvement in throughput of approximately (0.7, 0.7, 0.5) mag in (J , H , K_s).

field. The calibrated supernova magnitude is the WHIRC instrument magnitude plus the zeropoint as described in Equation 5. The SN Ia light curves in the WHIRC natural system are presented in Table 8.

5. DATA

With this data release we publish processed stacked images, photometric catalogs for each stacked images, light curves for each 2MASS star in each field, and light curves of supernovae which have little enough host-galaxy background light that reliable light curves could be generated without subtraction of reference images.

Table 9 summarizes the observations and resulting supernova light curves after the processing described in Section 3. Table 10 lists each of the stacked images along with their filter, date, and for SN fields, the approximate phase of the observation. These are the original estimates of the phase – refer to the actual lightcurve files for more accurate phases. Figure 8 shows postage stamp images of the 74 supernovae whose images are included in this release.

5.1. Lightcurves of 2MASS stars

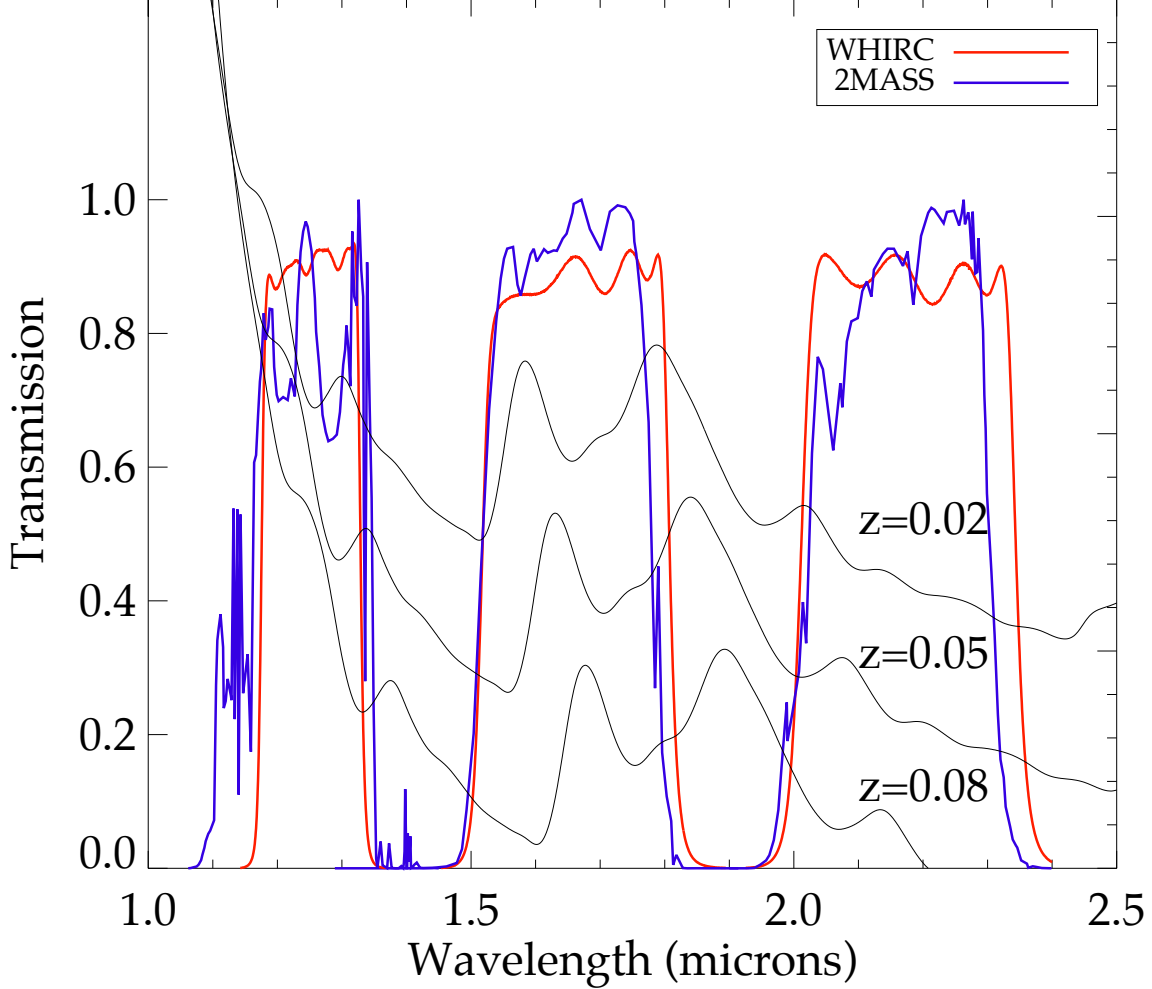


Figure 7. Filter transmission for WHIRC compared with 2MASS system response function. Over-plotted is a synthetic spectrum for a Type Ia which is 30 days old from Hsiao et al. (2007) at three different redshifts (with arbitrary ordinate offset for clarity). Note the significant bumps in the NIR spectrum that move out of the J - and H -band filters from $0 < z < 0.1$. A J - and H -band only version of this figure was shown in Weyant et al. (2014). These filter transmissions function curves were not used in determination of the WIYN+WHIRC natural system that we present here, which is based purely on color terms from broad-band colors. Note that because the WHIRC transmission curves do not include the optics, and more importantly the atmosphere, this figure isn’t quantitatively correct, but it illustrates the key point of the different wavelength cutoffs (filter edges) in the system response. Despite this inconsistency, this figure still illustrates that expected the color terms to convert from the WHIRC system to the 2MASS system should be positive. That is, for the same total counts in the WHIRC system, a redder star will be fainter in the 2MASS system than in the WHIRC system.

We present JHK_s light curves for 786 2MASS stars plus the 6 Persson standards (denoted by the Persson catalog name rather than their 2MASS names, see Table 4). These “2MASS stars” are based on the 2MASS classification as a star (point-like object). We have *not* updated these star/galaxy classification based on our higher-resolution WIYN+WHIRC data. Thus some of the 2MASS “stars” for which we report light curves are likely galaxies or blended stars.

5.2. Lightcurves of Supernovae

Table 8 presents JHK_s light curves for the 33 SNe Ia that were sufficiently isolated from the background of their host galaxy to lead to accurate light curves. The light curves for these supernovae are presented in Figure 9. Five isolated supernovae did not have good images. We have obtained template images of the host galaxies for the remaining 43 SNe Ia over the 2013A–2016A semesters. Light curves for these supernovae will be presented in a future data release.

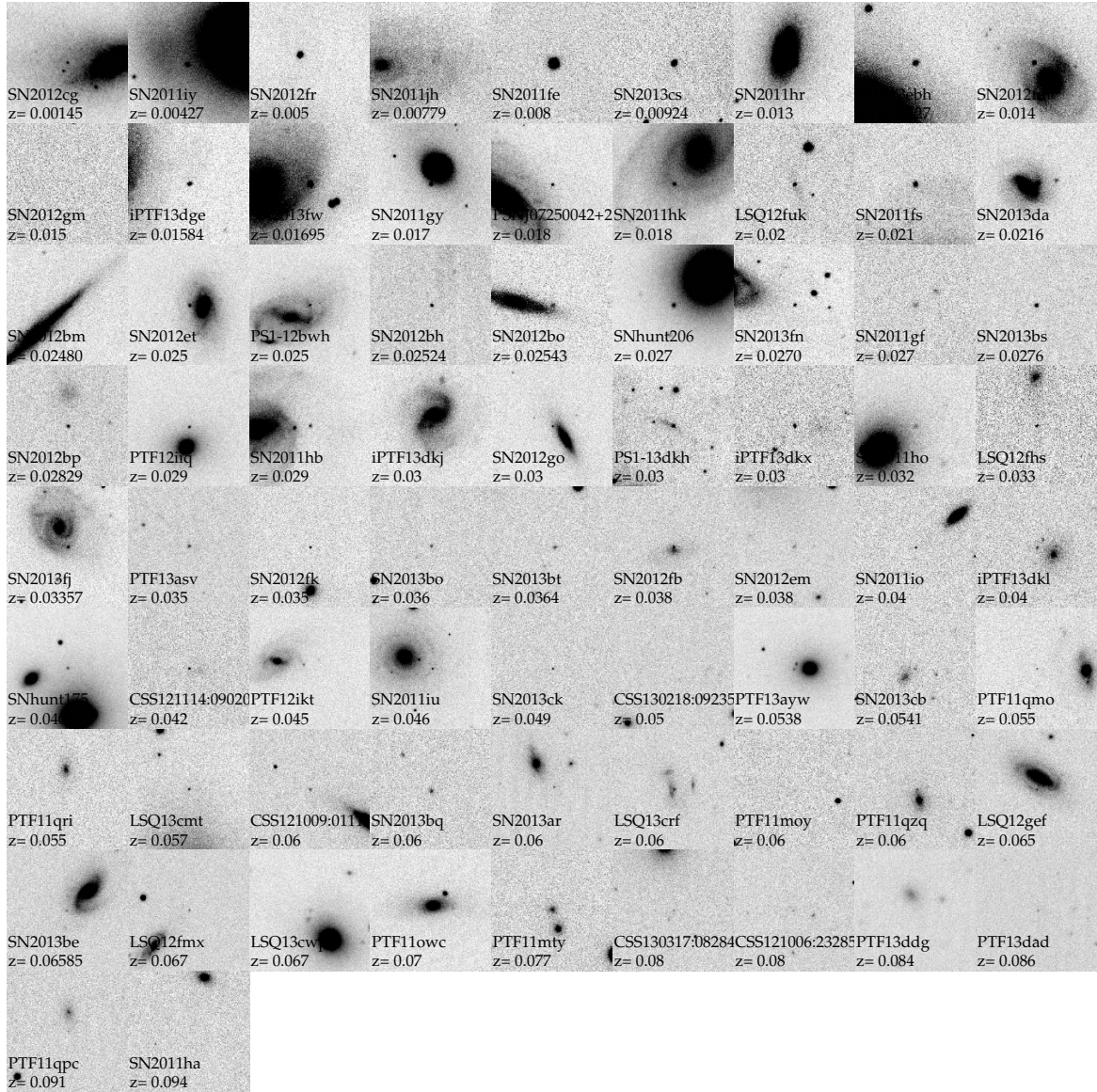


Figure 8. H -band images of the 74 SNe Ia presented in this data release from our WIYN+WHIRC stacked images. The stamps are oriented North up, East left. The SN is at the center of each postage stamp. The SNe are presented in order of increasing redshift. Each image is $40'' \times 40''$ square. Note that the image for SN 2011bh is from the host galaxy template. The “live” supernovae observations for SN 2011bh were not successfully processed by our current pipeline. Please see online version of paper for a full-resolution version of this figure.

We here detail the processing and provide specific information about file names and structure that describe the data as released. Raw data are available through the NOAO Science Archive. Processed data – stacks, catalogs, and light curves – are available at http://www.phyast.pitt.edu/~wmwv/SweetSpot/DR1_data/. Subdirectories listed below are with respect to this URL.

- **raw data** The raw data, both science data and calibration frames, are available through the standard interface to the NOAO Science Archive. All raw data presented in this data release have been now released as non-proprietary as the standard NOAO 18-month waiting period has elapsed.
- **stacks** We provide coadded stacked images for each observations which succeeded in processing through to this stage. This includes some stacks with poor WCS solutions – see Table 5 for details. These images are named as *FIELD_SET_FILTER_YYYYMMDD.fits*. E.g., *iPTF13dkx_A_H_20130927.fits* is an observation of the field of the supernova iPTF13dkx, the first set of observations during that night (“A”), in filter H , taken on 2013-09-27. Similarly *P212-C.B.KS_20130420.fits* is an observation of the field of the standard

Fig. Set 1. Supernova Light Curves

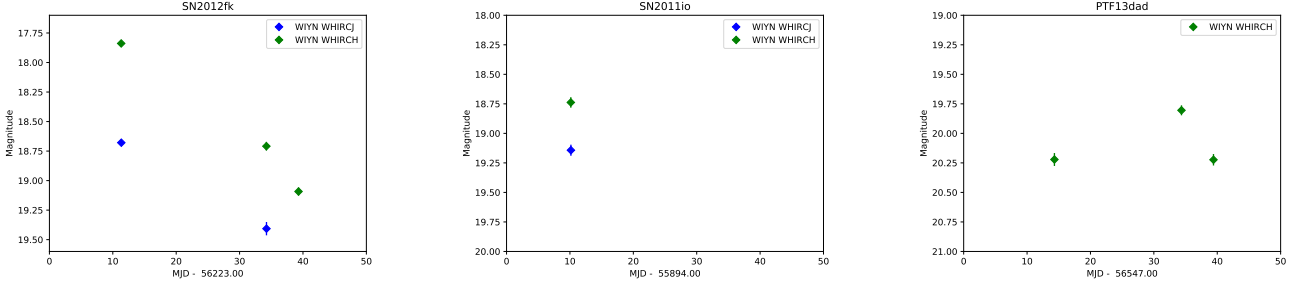


Figure 9. Lightcurves for the 33 SNe Ia with light curves presented in this paper. The individual light curve plots have been roughly normalized with respect to an estimated B -band maximum. The time of B -band maximum light was taken as that reported from the spectral classification in the respective ATel or CBET. We here show three representative light curves: SN 2012fk ($z = 0.035$), SN 2011io ($z = 0.04$), and PTF13dad ($z = 0.086$). The complete figure set of 33 images is available in the online journal.

star “P212-C”, it is the the second such observation during the night (“B”), in filter K_s , taken on 2013-04-20. A “set” is defined for each observation at a different airmass during the night. For almost all SN targets this will always be “A” as observations were carried out contiguously. However, we intentionally observed standard star fields at up to three different airmasses during a night, and each of these will be assigned a different set: “A”, “B”, or “C”. The effective exposure time for the coadded image varies discretely across the image due to the steps in the dithering (see Figure 4). The exposure map image is provided as an accompanying file with the same name, but with a suffix of *.expmap.fits*. These FITS images are available in the *stacks* subdirectory.

- **uncalibrated catalogs** We provide the astrometrically calibrated but photometrically *uncalibrated* catalogs for each image stack that passed basic quality control. They are named following the image they were generated from. E.g., *iPTF13dkx_A_H_20130927_photometry.fits*. These are catalogs are available as FITS binary tables in the *photometry.catalogs* directory.
- We provide summary files of our photometrically *uncalibrated* measurements of all 2MASS stars as *star_catalogs/ALL_2MASS_star_measurements.fits* and the subset of our 71 measurements of the 6 Persson standard stars as *Persson_standards/ALL_Persson_star_measurements.fits*. Per-night compilations of 2MASS stars are available in *star_catalogs*, while per-object compilations of the Persson standards are available in *Persson_standards*.
- **calibrated catalogs** We provide astrometrically and photometrically calibrated catalogs for each image stack that passed basic quality control. They are named as calibrated photometry following the image they were generated from. E.g., *iPTF13dkx_A_H_20130927_calibrated_photometry.fits*. These are available as FITS binary tables in the *catalogs* subdirectory.
- **star light curves** We provide as individual files the light curves of all 2MASS stars in these images. These light curve files are in the “Wstd” format used in ESSENCE project Miknaitis et al. (2007), and have names of the form *SN2012et_2MASS23423292+2705046.Wstd.dat*. The first token “SN2012et” denotes the field, while the second denotes the target by its 2MASS star name, “2MASS23423292+2705046” which also encodes the 2MASS RA, Dec. These text files are available in the *lightcurves* subdirectory.
- **SN light curves** We provide light curves of all the supernovae that we determined to be sufficiently separated from any significant contamination from their host galaxy. These files are named in the style of “SN2012et_SN2012et.Wstd.dat”, for the field “SN2012et” and the target “SN2012et”. While this appears a bit redundant, it provides a consistent scheme between the stars and the supernova associated with the same field. We also provide a version of the SN light curves in the “SNPY” format suitable for import into the SNooPy light-curve fitting framework. These light-curve files contain the same information as presented here in Table 8. These text files are available in the *lightcurves* subdirectory.

7. CONCLUSION AND FUTURE DIRECTIONS

SweetSpot has completed its original 3-year program as an NOAO survey to image nearby SNe Ia in the NIR using WHIRC at the WIYN 3.5m Observatory at Kitt Peak. This paper represents the first substantive data release from this survey. We presented 493 processed and calibrated images for 74 SNe Ia along with accompanying photometric catalogs. We also presented 33 SN light curves from 2011B–2013B, which includes the first 3 semesters (2012B, 2013A, 2013B) of the formal NOAO 2012B-0500 and also includes a re-analysis of the supernovae observed in the pilot survey (2011B, 2012A).

In collaboration with Peter Milne, we have obtained optical photometry with Super-LOTIS²⁹ for half of the SNe Ia presented here. We will present these data in a future paper. Many of the SNe Ia we have presented here in this paper have been observed by others who have obtained optical photometric and spectroscopic data. We hope that the release of these present NIR data will prompt further work with joint analyses of optical and NIR properties of these SNe Ia.

A key current need in the field of NIR SN Ia work is the development of an updated model of K-corrections based on the latest NIR spectroscopic data, and accurate calibration between the various NIR photometric systems in use.

The second and full data release (DR2) is planned for Fall 2017 and will include data from the remaining 3 semesters of SweetSpot. DR2 will also provide subtraction of host galaxy template images to provide light curves for all SweetSpot SNe Ia.

Author Contributions: Anja Weyant led the observational program and contributed to the image processing and light curve. Michael Wood-Vasey is PI of SweetSpot and developed the bulk of the 2D image pipeline (based on the work of Ralf Kotulla) and also calibrated the observations and light curves. Richard Joyce provided expertise in processing of the WHIRC data and instrument support/trouble-shooting in the early stages of the survey. Lori Allen observed several nights at the WIYN 0.9-m in support of this program, and was the project contact for ensuring this NOAO 2012B-0500 program was appropriately scheduled. Saurabh Jha was one of the developers of the SweetSpot project. Peter Garnavich was one of the developers of the SweetSpot project and advised on target selection. Tom Matheson was one of the developers of the SweetSpot project and contributed to science priority and observation planning and presented the status of the project at annual NOAO reviews. Kara Ponder observed several nights at WIYN and oversaw image quality inspection. Jessica Kroboth did the bulk of the processed image inspection.

We acknowledge the observing contributions of Nabila Jahan and Brandon Patel who each participated in a night of observing.

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We express our thanks to the hard-working groups who discover and provide rapid spectroscopic classification of SNe Ia that have allowed our follow-up program to be viable. The “Latest Supernovae” website³⁰ maintained by David Bishop was helpful in planning and executing these observations.

We thank the Tohono O’odham Nation for leasing their mountain to allow for astronomical research.

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²⁹ <http://slotis.kpno.noao.edu/LOTIS/>

³⁰ <http://www.rochesterastronomy.org/supernova.html>

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PyRAF is a product of the Space Telescope Science Institute, which is operated by AURA for NASA.

This research has made use of the VizieR catalog access tool, CDS, Strasbourg, France.

Facility: WIYN

Software: IRAF, Python³¹, NumPy³², SciPy³³, matplotlib (Hunter 2007)³⁴, AstroPy (Astropy Collaboration et al. 2013)³⁵, IDL³⁶

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³¹ <http://python.org>

³² <http://www.numpy.org>

³³ <http://www.scipy.org>

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Table 1. Summary of awarded nights of NOAO time

Semester	Awarded Nights	Usable Nights ^a
2011B	7.0	3.5
2012A	1.0	1.0
2012B	8.0	8.0
2013A	10.5	9.0
2013B	10.5	8.0

^aEffective total nights during which we obtained on-sky data. The majority of the difference is due to bad weather, with some contribution from instrument failures.

Table 2. Nights Observed

Date ^a	# Observations SN ^b	Persson ^c	Photometric
2011-10-25	12	0	No
2011-11-15	16	0	Yes
2011-11-21	8	0	No
2011-12-08	25	0	No
2012-01-08	20	0	Yes
2012-04-02	21	0	Yes
2012-09-25	12	0	No
2012-10-01	11	0	No
2012-10-07	12	0	No
2012-10-28	17	0	No
2012-11-02	21	2	Yes
2012-11-22	21	9	Yes
2012-11-25	22	17	Yes
2012-11-30	22	9	No
2013-03-21	1	0	No
2013-03-26	5	2	No
2013-04-20	15	8	No
2013-04-25	15	4	No
2013-04-29	11	5	No
2013-05-19	10	5	Yes
2013-05-22	6	6	No
2013-05-23	12	9	No
2013-05-28	12	12	Yes
2013-06-13	14	6	Yes
2013-06-17	15	6	Yes
2013-09-25	10	10	Yes
2013-09-27	11	18	No
2013-10-15	19	21	Yes
2013-10-18	10	6	Yes

Table 2 continued on next page

Table 2 (*continued*)

Date ^a	# Observations		Photometric
	SN ^b	Persson ^c	
2013-10-19	7	7	Yes
2013-10-20	18	16	Yes
2013-10-25	5	0	Yes
2013-11-11	17	15	No
2013-11-20	10	1	No
2013-12-09	15	12	No
2013-12-13	15	11	Yes

^a YYYY-MM-DD of local evening at KPNO (MST).

^b Each SN-filter combination is counted separately.

^c Each standard-filter-airmass observation is counted separately.

Table 3. SN Ia Properties from the Literature

Name	Dec	RA	Spec.	SN z_{helio}	Classifier/ Redshift ^a	Discoverer ^a	est. ^b T_{Bmax} MJD	Lightcurve
		J2000	Type					
CSS121006:232854+085452	23:28:54.48	+08:54:51.6	Ia	0.08	D12b	D12c	56207	Yes
CSS121009:011101-172841	01:11:01.091	-17:28:42.28	Ia	0.06	D12b	D12c	56220	Yes
CSS121114:090202+101800	09:02:02.420	+10:18:00.31	Ia	0.042	G12	D12a	56252	Yes
CSS130218:092354+385837	09:23:54.52	+38:58:36.8	Ia	0.05	D13b	D13a	56361	No
CSS130317:082848+293031	08:28:47.784	+29:30:30.85	Ia	0.08	D13b	D13b	56370	No
LSQ12fhs	22:52:23.423	-20:36:53.35	91T	0.033	CO12	CO12	56215	Yes
LSQ12fmx	03:12:52.144	-00:12:12.55	Ia	0.067	BN12	BN12	56227	Yes
LSQ12fuk	04:58:15.927	-16:17:58.14	Ia	0.02	H12	H12	56232	No
LSQ12gef	01:40:33.751	+18:30:36.74	Ia	0.065	CL12	CL12	56247	No
LSQ13cmt	01:02:41.95	-21:52:23.4	Ia	0.057	CT13	CT13	56575	Yes
LSQ13crf	03:10:50.263	+01:25:19.19	Ia	0.06	Tu13	Tu13	56596	No
LSQ13cwp	04:03:50.662	-02:39:18.57	Ia	0.067	WK13	WK13	56606	Yes
PS1-12bwh	07:09:24.29	+39:06:15.8	02cx	0.025	W12	W12	56222	No
PS1-13dkh	03:11:16.09	+15:42:58.3	91T	0.03	Fo13	Fo13	56572	Yes
PSNJ07250042+2347030	07:25:00.408	+23:47:03.15	Ia	0.018	BT12	BT12	56218	No
PTF11moy	17:06:18.06	+38:32:19.9	Ia	0.06	GY11a	GY11a	55824	Yes
PTF11mtty	21:34:05.20	+10:25:24.6	Ia	0.077	GY11d	GY11d	55835	No
PTF11owc	09:16:10.05	+49:37:30.7	Ia	0.07	GY11c	GY11c	55867	No
PTF11qmo	10:06:49.748	-07:41:12.39	Ia	0.055	GY11b	GY11b	55894	Yes
PTF11qpc	12:20:05.457	+09:24:12.38	Ia	0.091	GY11b	GY11b	55902	No
PTF11qri	12:47:06.276	-06:19:49.46	Ia	0.055	GY11b	GY11b	55897	Yes
PTF11qzq	07:19:27.311	+54:13:48.84	Ia	0.06	GY11b	GY11b	55905	No
PTF12iiq	02:50:07.786	-00:15:54.04	Ia	0.029	GY12	GY12	56179	No
PTF12ikt	01:14:43.13	+00:17:07.1	Ia	0.045	GY12	GY12	56182	No
PTF13asv	16:22:43.19	+18:57:35.0	Ia	0.035	C13d	C13d	56423	Yes
PTF13ayw	15:39:33.479	+32:05:38.33	Ia	0.0538	C13d	C13d	56430	No
PTF13dad	01:48:08.39	+37:33:29.1	Ia	0.086	C13e	C13e	56547	Yes
PTF13ddg	00:47:50.83	+31:49:17.5	Ia	0.084	C13e	C13e	56545	Yes

Table 3 continued on next page

Table 3 (*continued*)

Name	Dec	RA	Spec.	SN z_{helio}	Classifier/ Redshift ^a	Discoverer ^a	est. ^b T_{Bmax} MJD	Lightcurve
	J2000		Type					
SN 2011fe	14:03:05.80	+54:16:25.3	Ia	0.008	Nu11	Nu11	55814	Yes
SN 2011fs	22:17:19.509	+35:34:49.94	Ia	0.021	BM11; To11b	J11a	55833	Yes
SN 2011gf	21:12:24.302	−07:48:52.04	Ia	0.027	V11; M11	D11	55827	Yes
SN 2011gy	03:29:35.319	+40:52:02.93	Ia	0.017	Ta11; Z11a	J11b	55865	No
SN 2011ha	03:57:40.87	+10:09:55.2	Ia	0.094	O11	Li11	55840	No
SN 2011hb	23:27:55.508	+08:46:45.45	Ia	0.029	MB11a	Ho11a	55872	No
SN 2011hk	02:18:45.801	−06:38:30.45	91bg	0.018	MB11b	N11	55864	No
SN 2011ho	11:44:13.060	+33:30:59.89	Ia	0.032	Fo11b; MB11c	Ho11b	55865	No
SN 2011hr	08:54:46.056	+39:32:16.02	91T	0.013	Z11b	Na11	55883	No
SN 2011io	23:02:47.617	+08:48:08.12	Ia	0.04	Fr11	Ba11	55894	Yes
SN 2011iu	23:51:02.342	+46:43:21.55	Ia	0.046	MB11d	Cox11	55894	No
SN 2011iy	13:08:58.38	−15:31:04.0	Ia	0.00427	CJ11; Y11	I11	55896	Yes
SN 2011jh	12:47:14.42	−10:03:47.2	Ia	0.00779	To11a	NN11	55929	Yes
SN 2012bh	12:13:37.325	+46:29:00.34	Ia	0.02524	CK12	CK12	56016	Yes
SN 2012bm	13:05:45.621	+46:27:52.39	Ia	0.0248	Ca12a	P12	56021	No
SN 2012bo	12:50:45.215	−14:16:07.69	Ia	0.02543	Ca12b; DT12	I12	56021	Yes
SN 2012bp	16:18:12.451	+36:28:51.87	Ia	0.02829	Pa12	Li12b	56013	Yes
SN 2012cg	12:27:12.826	+09:25:12.93	Ia	0.00145	Ce12; M12	Ka12	56018	No
SN 2012em	22:44:01.66	+15:51:49.3	91bg	0.038	Be12; TD12	Mi12	56181	Yes
SN 2012et	23:42:38.747	+27:05:31.02	Ia	0.025	De12	R12a	56186	No
SN 2012fb	01:50:51.238	+33:08:24.17	Ia	0.038	CW12	Zh12	56195	No
SN 2012fk	02:30:52.081	+22:28:46.02	Ia	0.035	To12	Li12a	56223	Yes
SN 2012fm	06:56:13.39	+84:04:50.2	Ia	0.014	Za12	Di12	56228	No
SN 2012fr	03:33:35.99	−36:07:37.7	Ia	0.005	CS12; B12	Kl12	56240	No
SN 2012gm	23:17:37.055	+14:00:08.89	Ia	0.015	O12	R12b	56260	No
SN 2012go	22:41:51.848	+34:58:07.39	Ia	0.03	Ke12; Ko12	Ar12	56252	No
SN 2013ar	08:37:45.02	+49:28:32.2	Ia	0.06	ZJ13; To13c	Zh13c	56374	Yes
SN 2013be	12:36:27.638	+11:45:27.96	Ia	0.06585	S13	Zh13b	56398	No
SN 2013bo	13:17:29.19	+42:44:29.6	Ia	0.036	To13b	D13c	56393	No
SN 2013bq	13:04:08.45	+43:54:07.7	Ia	0.06	To13d	D13d	56406	No
SN 2013bs	17:17:22.03	+41:04:00.2	Ia	0.0276	To13e	D13e	56403	Yes
SN 2013bt	14:21:15.185	+61:34:15.42	Ia	0.0364	To13f	D13f	56408	Yes
SN 2013cb	11:35:01.736	+16:07:14.91	Ia	0.0541	To13g; Gao13	Zh13d	56424	No
SN 2013ck	15:24:29.105	+48:32:54.53	Ia	0.049	To13a	D13g	56424	No
SN 2013cs	13:15:14.839	−17:57:55.24	Ia	0.00924	Y13	Ho13a	56436	Yes
SN 2013da	13:45:36.338	−07:19:33.69	Ia	0.0216	Pr13a	Pr13a	56449	No
SN 2013fj	22:15:28.480	+15:34:03.19	Ia	0.03357	ZT13	Cia13	56545	No
SN 2013fn	21:00:23.673	−14:29:52.42	Ia	0.027	Mo13; MC13	Ho13b	56572	Yes
SN 2013fw	21:13:44.763	+13:34:33.33	Ia	0.01695	HL13	J13	56603	No
SNhunt175	15:19:24.978	+20:54:01.61	Ia	0.0409	Pr13b	Pr13b	56369	No
SNhunt206	01:58:42.759	+08:20:39.51	Ia	0.027	Ke13	Ke13	56548	No
iPTF13dge	05:03:35.091	+01:34:17.03	Ia	0.01584	C13b	C13b	56555	No
iPTF13dkj	23:08:50.737	+20:04:08.59	Ia	0.03	C13a	C13a	56555	No
iPTF13dkl	23:44:57.999	+03:23:40.07	Ia	0.04	C13a	C13a	56556	Yes
iPTF13dkx	01:20:53.115	+03:20:23.65	Ia	0.03	C13a	C13a	56561	Yes
iPTF13ebh	02:21:59.98	+33:16:13.7	Ia	0.01327	C13c	C13c	56619	Yes

Table 3 continued on next page

Table 3 (*continued*)

Name	Dec	RA	Spec. Type	SN z_{helio}	Classifier/ Redshift ^a	Discoverer ^a	est. ^b T_{Bmax} MJD	Lightcurve
		J2000						

^a SN classifier/redshift and discovery references are: Ar12 [Arbour et al. \(2012\)](#), B12 [Buil \(2012\)](#), BM11 [Balam et al. \(2011\)](#), BN12 [Benitez et al. \(2012\)](#), BT12 [Buton et al. \(2012\)](#), Ba11 [Balanutsa & Lipunov \(2011\)](#), Be12 [Benetti et al. \(2012\)](#), C13a [Cao et al. \(2013a\)](#), C13b [Cao et al. \(2013b\)](#), C13c [Cao et al. \(2013c\)](#), C13d [Cao et al. \(2013d\)](#), C13e [Cao et al. \(2013e\)](#), CJ11 [Chen et al. \(2011\)](#), CK12 [Chornock et al. \(2012\)](#), CL12 [Cellier-Holzem et al. \(2012\)](#), CO12 [Copin et al. \(2012\)](#), CS12 [Childress et al. \(2012\)](#), CT13 [Chen et al. \(2013\)](#), CW12 [Caldwell \(2012\)](#), Ca12a [Cappellaro et al. \(2012a\)](#), Ca12b [Cappellaro et al. \(2012b\)](#), Ce12 [Cenko et al. \(2012\)](#), Cia13 [Ciabattari et al. \(2013\)](#), Cox11 [Cox et al. \(2011\)](#), D11 [Drake et al. \(2011\)](#), D12a [Drake et al. \(2012a\)](#), D12b [Drake et al. \(2012b\)](#), D12c [Drake et al. \(2012c\)](#), D13a [Drake et al. \(2013a\)](#), D13b [Drake et al. \(2013b\)](#), D13c [Drake et al. \(2013c\)](#), D13d [Drake et al. \(2013d\)](#), D13e [Drake et al. \(2013e\)](#), D13f [Drake et al. \(2013f\)](#), D13g [Drake et al. \(2013g\)](#), DT12 [Drout et al. \(2012\)](#), De12 [Dennefeld et al. \(2012\)](#), Di12 [Dimai et al. \(2012\)](#), Fo11b [Foley et al. \(2011\)](#), Fo13 [Foley et al. \(2013\)](#), Fr11 [Fraser et al. \(2011\)](#), G12 [Graham et al. \(2012\)](#), GY11a [Gal-Yam et al. \(2011a\)](#), GY11b [Gal-Yam et al. \(2011b\)](#), GY11c [Gal-Yam et al. \(2011c\)](#), GY11d [Gal-Yam et al. \(2011d\)](#), GY12 [Gal-Yam et al. \(2012\)](#), Gao13 [Gao et al. \(2013\)](#), H12 [Hadjiyska et al. \(2012\)](#), HL13 [Howell et al. \(2013\)](#), Ho11a [Howerton et al. \(2011a\)](#), Ho11b [Howerton et al. \(2011b\)](#), Ho13a [Howerton et al. \(2013a\)](#), Ho13b [Howerton et al. \(2013b\)](#), I11 [Itagaki et al. \(2011\)](#), I12 [Itagaki et al. \(2012\)](#), J11a [Jin et al. \(2011\)](#), J11b [Jin & Gao \(2011\)](#), J13 [Jin et al. \(2013\)](#), Ka12 [Kandrashoff et al. \(2012\)](#), Ke12 [Kankare et al. \(2012\)](#), Ke13 [Kankare et al. \(2013\)](#), Kl12 [Klotz et al. \(2012\)](#), Ko12 [Kotak et al. \(2012\)](#), Li11 [Lipunov & Balanutsa \(2011\)](#), Li12a [Lipunov et al. \(2012a\)](#), Li12b [Lipunov et al. \(2012b\)](#), M11 [Marion \(2011\)](#), M12 [Marion et al. \(2012\)](#), MB11a [Marion & Berlind \(2011a\)](#), MB11b [Marion & Berlind \(2011b\)](#), MB11c [Marion & Berlind \(2011c\)](#), MB11d [Marion & Berlind \(2011d\)](#), MC13 [Milisavljevic \(2013\)](#), Mi12 [Mikuz et al. \(2012\)](#), Mo13 [Mo et al. \(2013\)](#), N11 [Nakano \(2011\)](#), NN11 [Nakano & Noguchi \(2011\)](#), Na11 [Nayak et al. \(2011\)](#), Nu11 [Nugent et al. \(2011\)](#), O11 [Ochner et al. \(2011\)](#), O12 [Ochner et al. \(2012\)](#), P12 [Puckett et al. \(2012\)](#), Pa12 [Pastorello et al. \(2012\)](#), Pr13a [Prieto et al. \(2013\)](#), Pr13b [Prieto \(2013\)](#), R12a [Rich et al. \(2012a\)](#), R12b [Rich et al. \(2012b\)](#), S13 [Silverman et al. \(2013\)](#), TD12 [Taddia \(2012\)](#), Ta11 [Taubenberger et al. \(2011\)](#), To11a [Tomasella et al. \(2011a\)](#), To11b [Tomasella et al. \(2011b\)](#), To12 [Tomasella et al. \(2012\)](#), To13a [Tomasella et al. \(2013a\)](#), To13b [Tomasella et al. \(2013b\)](#), To13c [Tomasella et al. \(2013c\)](#), To13d [Tomasella et al. \(2013d\)](#), To13e [Tomasella et al. \(2013e\)](#), To13f [Tomasella et al. \(2013f\)](#), To13g [Tomasella et al. \(2013g\)](#), Tu13 [Turatto et al. \(2013\)](#), V11 [Valenti et al. \(2011\)](#), W12 [Wright et al. \(2012\)](#), WK13 [Walker et al. \(2013\)](#), Y11 [Yamanaka et al. \(2011\)](#), Y13 [Yamanaka et al. \(2013\)](#), Z11a [Zhang et al. \(2011a\)](#), Z11b [Zhang et al. \(2011b\)](#), ZJ13 [Zhang et al. \(2013a\)](#), ZT13 [Zanutta et al. \(2013\)](#), Za12 [Zaggia et al. \(2012\)](#), Zh12 [Zheng et al. \(2012\)](#), Zh13b [Zhang et al. \(2013b\)](#), Zh13c [Zhang et al. \(2013c\)](#), Zh13d [Zhang et al. \(2013d\)](#),

^b Time of maximum in the *B*-band reported in CBET/ATel.

Table 4. Persson Photometric Standard Stars

Name	2MASS ID	Persson Catalog Magnitudes			2MASS Catalog Magnitudes		
		m_J [mag]	m_H [mag]	m_{K_s} [mag]	m_J [mag]	m_H [mag]	m_{K_s} [mag]
P212-C	10062887+4101245	11.993 ± 0.006	11.729 ± 0.005	11.697 ± 0.007	11.939 ± 0.014	11.747 ± 0.014	11.662 ± 0.016
S791-C	13172933-0532383	11.661 ± 0.008	11.310 ± 0.007	11.267 ± 0.008	11.677 ± 0.025	11.318 ± 0.022	11.275 ± 0.023
P330-E	16313382+3008465	11.816 ± 0.007	11.479 ± 0.005	11.429 ± 0.006	11.781 ± 0.018	11.453 ± 0.018	11.432 ± 0.020
P525-E	00242846+0749005	11.622 ± 0.005	11.298 ± 0.005	11.223 ± 0.005	11.642 ± 0.025	11.297 ± 0.021	11.224 ± 0.021
P161-D	07005180+4829231	11.680 ± 0.006	11.408 ± 0.006	11.352 ± 0.006	11.682 ± 0.017	11.385 ± 0.015	11.326 ± 0.016
S840-F	05423214+0009019	11.426 ± 0.009	11.148 ± 0.009	11.058 ± 0.008	11.441 ± 0.021	11.125 ± 0.020	11.070 ± 0.019

Table 5. Stack Inspection

imageName	stackUsable	wcsGood
PTF11moy_A_H_20111025.fits	Y	Y
PTF11moy_A_J_20111025.fits	Y	Y
PTF11mtty_A_H_20111025.fits	Y	Y
PTF11mtty_A_J_20111025.fits	Y	Y
SN2011fe_A_H_20111025.fits	Y	Y
SN2011fe_A_J_20111025.fits	Y	Y
SN2011fe_A_KS_20111025.fits	Y	Y
SN2011fs_A_H_20111025.fits	Y	Y
SN2011fs_A_J_20111025.fits	Y	Y
SN2011fs_A_KS_20111025.fits	Y	Y

97.3% of the stacks are usable. 97.2% of the stacks have good WCS. 96.2% of the stacks are usable and have good WCS. Note that there are a few stacks that are not usable but have good WCS: e.g., the stack may have ended up with only one constituent raw image and so have many masked regions, but has a good WCS solution. (This table is a stub to show the structure. See the online version for the full table.)

Table 6. Photometric Calibration Terms

Filter	2011B–2013A	2013B	k [mag/airmass]	c [mag/mag]
	zeropoint [mag]	zeropoint [mag]		
J	22.5801 ± 0.01	23.1998 ± 0.01	0.0812 ± 0.02	$+0.2846 \pm 0.03$
H	22.7300 ± 0.01	23.3014 ± 0.01	0.0470 ± 0.02	$+0.0635 \pm 0.03$
K_s	22.2076 ± 0.01	22.5684 ± 0.01	0.0094 ± 0.02	$+0.1144 \pm 0.03$

Table 7. 2MASS Calibration Stars

2MASS ID	Field	WHIRC						2MASS					
		J mag	σ_J mag	H mag	σ_H mag	K_s mag	σ_{K_s} mag	J mag	σ_J mag	H mag	σ_H mag	K_s mag	σ_{K_s} mag
23285863+0854063	CSS121006:232854+085452	...	...	15.137	0.011	...	...	15.469	0.063	15.022	0.088	14.849	0.112
01105481-1728484	CSS121009:011101-172841	13.813	0.015	13.537	0.015	...	...	14.252	0.028	13.591	0.034	13.480	0.045
09015664+1017118	CSS121114:090202+101800	15.327	0.010	14.802	0.010	...	...	15.322	0.054	14.818	0.054	14.679	0.105
09240185+3858360	CSS130218:092354+385837	...	...	14.612	0.011	...	...	15.258	0.047	14.706	0.070	14.445	0.069
08285459+2929165	CSS130317:082848+293031	12.956	0.011	12.157	0.010	...	...	12.768	0.023	12.127	0.019	11.989	0.022
22521836-2038146	LSQ12fhs	15.039	0.018	14.354	0.017	...	...	14.962	0.041	14.322	0.046	14.213	0.060
03125316-0012084	LSQ12fmx	14.596	0.011	14.295	0.011	...	...	14.510	0.032	14.236	0.032	14.066	0.065
04581563-1617462	LSQ12fuk	12.845	0.015	12.302	0.015	...	...	12.899	0.024	12.277	0.023	12.075	0.024
01403113+1831584	LSQ12gef	12.576	0.010	11.999	0.010	...	...	12.818	0.024	12.128	0.026	11.937	0.020
01025011-2151228	LSQ13cmt	14.921	0.017	14.416	0.017	...	...	15.683	0.059	15.102	0.057	14.882	0.104
03105792+0125138	LSQ13crf	12.707	0.011	12.373	0.011	...	...	12.717	0.024	12.310	0.029	12.201	0.021
04035391-0238401	LSQ13cwp	11.779	0.011	11.494	0.011	...	...	11.775	0.023	11.491	0.024	11.386	0.023
07092861+3906536	PS1-12bwh	14.751	0.010	14.407	0.010	...	...	14.682	0.039	14.308	0.049	14.329	0.062
03111139+1542476	PS1-13dkh	12.760	0.010	12.211	0.010	...	...	12.792	0.023	12.212	0.028	12.083	0.022
07245876+2348557	PSNJ07250042+2347030	14.417	0.010	14.003	0.010	...	...	14.395	0.030	13.968	0.041	13.915	0.037
17061982+3832029	PTF11moy	15.725	0.017	15.254	0.021	...	...	15.726	0.067	15.165	0.102	15.068	0.122
21340153+1025244	PTF11mty	15.047	0.015	14.678	0.018	...	...	15.118	0.047	14.667	0.063	14.565	0.090
09161694+4938008	PTF11owc	15.439	0.010	14.886	0.011	...	...	15.736	0.065	15.073	0.068	14.843	0.087
10064651-0740348	PTF11qmo	11.832	0.012	11.639	0.013	...	...	12.035	0.022	11.791	0.022	11.737	0.024
12201145+0923443	PTF11qpc	...	...	12.432	0.010	...	...	12.531	0.021	12.239	0.025	12.187	0.026
12470715-0620106	PTF11qri	15.256	0.015	14.707	0.017	...	...	15.017	0.029	14.673	0.060	14.757	0.096
07192539+5413348	PTF11qzq	14.056	0.010	13.676	0.010	...	...	14.170	0.028	13.691	0.029	13.751	0.037
02500494-0015196	PTF12iiq	10.666	0.012	10.586	0.011	...	...	10.507	0.028	10.070	0.022	9.911	0.022
01143707+0015215	PTF12ikt	11.269	0.011	11.059	0.011	...	...	11.255	0.027	10.874	0.031	10.786	0.022
16224201+1856258	PTF13asv	...	...	14.982	0.011	...	...	15.718	0.064	14.923	0.062	14.818	0.080
15393516+3207091	PTF13ayw	15.755	0.014	15.096	0.012	...	...	15.988	0.070	15.345	0.102	14.990	0.103
01480916+3734125	PTF13dad	20.982	0.556	13.663	0.010	...	...	13.915	0.024	13.652	0.026	13.609	0.030
00475085+3151019	PTF13ddg	...	...	11.877	0.013	...	...	11.972	0.024	11.704	0.031	11.698	0.025
14025710+5416408	SN 2011fe	14.708	0.039	14.590	0.034	14.519	0.053	15.060	0.038	14.642	0.072	14.844	0.108
22171903+3535266	SN 2011fs	14.838	0.014	14.205	0.013	14.003	0.016	14.819	0.035	14.203	0.045	14.106	0.066
21122821-0747132	SN 2011gf	15.641	0.019	15.080	0.022	...	...	15.712	0.067	15.015	0.101	14.790	0.103
03293746+4052433	SN 2011gy	14.630	0.016	14.062	0.013	...	...	14.771	0.032	14.075	0.035	13.950	0.034
03573953+1008196	SN 2011ha	15.440	0.011	14.914	0.011	...	...	15.543	0.056	14.989	0.075	14.808	0.084
23275381+0847589	SN 2011hb	12.784	0.018	12.432	0.015	...	...	12.871	0.024	12.412	0.024	12.301	0.026
02184937-0637528	SN 2011hk	14.934	0.015	14.283	0.014	...	...	15.022	0.045	14.408	0.047	14.257	0.059
11440746+3330234	SN 2011ho	...	...	10.800	0.010	...	...	12.622	0.021	12.035	0.022	11.792	0.018
08544574+3933348	SN 2011hr	15.065	0.010	14.537	0.010	...	...	15.126	0.038	14.589	0.053	14.249	0.058
23024227+0848225	SN 2011io	16.017	0.012	15.620	0.011	...	...	15.732	0.070	15.163	0.090	14.966	0.128
23505722+4643151	SN 2011iu	15.204	0.012	14.578	0.011	...	...	15.323	0.051	14.685	0.055	14.467	0.078
13085417-1532148	SN 2011iy	14.030	0.016	13.535	0.015	...	...	14.129	0.026	13.601	0.027	13.510	0.037
12472073-1002493	SN 2011jh	12.356	0.013	12.086	0.012	...	...	12.353	0.023	12.024	0.022	11.972	0.024
12133551+4627088	SN 2012bh	14.834	0.010	14.597	0.010	...	...	15.110	0.040	14.511	0.057	14.464	0.071
13054793+4629189	SN 2012bm	14.393	0.014	14.722	0.013	...	...	15.271	0.042	14.625	0.059	14.226	0.048
12504489-1414194	SN 2012bo	15.745	0.021	15.274	0.024	...	...	15.606	0.055	15.193	0.087	15.117	0.150
16181090+3629229	SN 2012bp	15.503	0.011	15.296	0.010	...	...	15.588	0.062	15.147	0.085	15.203	0.151
12271948+0924165	SN 2012cg	14.285	0.010	13.506	0.010	...	...	14.664	0.041	14.106	0.053	13.784	0.058
22435933+1550085	SN 2012em	14.414	0.010	13.818	0.010	...	...	14.414	0.029	13.807	0.037	13.634	0.044

Table 7 continued on next page

Table 7 (*continued*)

2MASS ID	Field	WHIRC						2MASS					
		J	σ_J	H	σ_H	K_s	σ_{K_s}	J	σ_J	H	σ_H	K_s	σ_{K_s}
		mag	mag	mag	mag	mag	mag	mag	mag	mag	mag	mag	mag
23424027+2706047	SN 2012et	15.519	0.011	15.002	0.011	...	...	15.395	0.059	14.883	0.088	14.752	0.096
01505417+3308549	SN 2012fb	14.555	0.010	13.978	0.010	...	...	14.500	0.029	13.869	0.036	13.576	0.036
02305565+2227192	SN 2012fk	15.810	0.010	15.486	0.010	...	...	15.942	0.081	15.245	0.080	15.250	0.159
06552328+8405019	SN 2012fm	12.432	0.016	12.073	0.016	...	...	12.507	0.022	12.085	0.030	12.007	0.023
03333369+3607144	SN 2012fr	12.209	0.036	11.878	0.037	...	...	12.148	0.024	11.773	0.027	11.673	0.026
23173291+1359237	SN 2012gm	11.667	0.010	11.155	0.010	11.262	0.010	11.741	0.022	11.159	0.021	11.060	0.020
22414990+3458008	SN 2012go	14.143	0.010	13.923	0.010	...	...	14.114	0.025	13.673	0.017	13.735	0.050
08374071+4927483	SN 2013ar	15.767	0.010	14.866	0.010	...	...	15.415	0.043	14.693	0.061	14.518	0.068
12362858+1144499	SN 2013be	12.299	0.010	12.052	0.010	...	...	12.586	0.022	12.291	0.028	12.232	0.027
13173089+4244190	SN 2013bo	14.866	0.011	14.312	0.010	...	...	14.927	0.037	14.411	0.049	14.229	0.060
13041752+4354337	SN 2013bq	14.627	0.010	13.753	0.010	...	...	15.179	0.047	14.592	0.054	14.395	0.067
17171754+4105044	SN 2013bs	10.749	0.010	10.485	0.010	...	...	10.852	0.022	10.533	0.016	10.472	0.018
14211406+6134348	SN 2013bt	13.904	0.012	13.298	0.011	...	...	13.968	0.026	13.359	0.026	13.172	0.028
11350065+1608296	SN 2013cb	15.265	0.012	14.859	0.010	...	...	15.635	0.057	15.064	0.080	14.814	0.081
15242515+4834230	SN 2013ck	15.166	0.011	14.862	0.010	...	...	15.356	0.047	14.818	0.068	14.592	0.106
13151954+1757077	SN 2013cs	14.275	0.016	13.718	0.015	...	...	14.342	0.032	13.736	0.034	13.526	0.046
13454012+0718110	SN 2013da	15.488	0.013	15.017	0.012	...	...	15.266	0.046	14.919	0.068	14.814	0.128
22152384+1534390	SN 2013fj	15.182	0.012	14.823	0.013	...	...	15.253	0.046	14.762	0.050	14.758	0.134
21002395+1431048	SN 2013fn	15.920	0.014	15.501	0.014	15.412	0.016	16.007	0.069	15.396	0.086	15.377	0.138
21134413+1336121	SN 2013fw	13.034	0.010	12.720	0.010	14.043	0.010	13.007	0.025	12.633	0.026	12.576	0.025
15192067+2053326	SNhunt175	13.327	0.012	12.892	0.011	...	...	13.428	0.024	13.007	0.022	12.867	0.025
01583809+0820382	SNhunt206	15.056	0.012	14.475	0.011	...	...	15.189	0.042	14.522	0.052	14.351	0.081
05033130+0133109	iPTF13dge	16.395	0.011	15.638	0.011	15.070	0.012	15.571	0.100	14.756	0.101	14.264	0.101
23084927+2003397	iPTF13dkj	13.940	0.010	13.345	0.010	...	...	13.921	0.025	13.370	0.026	13.045	0.026
23445822+0325271	iPTF13dkl	14.479	0.012	14.227	0.012	...	...	14.940	0.039	14.280	0.058	14.183	0.063
01205658+0322007	iPTF13dkx	11.398	0.011	11.083	0.011	...	...	11.358	0.024	10.996	0.026	10.929	0.024
02215630+3316108	iPTF13ebh	15.885	0.011	15.473	0.010	15.278	0.012	15.937	0.067	15.501	0.122	15.331	0.156

Table 8. SweetSpot Lightcurves

Name	mjd d	approxPhase d	filter ^a	mag mag	magErr mag	flux ^b	fluxErr
CSS121006:232854+085452	56229.24133	22.24133	WHIRCH	20.47229	0.15856	64.7270	9.3859
CSS121006:232854+085452	56234.13280	27.13280	WHIRCH	20.10279	0.11054	90.9672	9.2300
CSS121009:011101-172841	56234.27359	14.27359	WHIRCJ	18.97756	0.05157	256.4340	12.1698
CSS121009:011101-172841	56229.31361	9.31361	WHIRCH	18.64361	0.04781	348.7850	15.3479
CSS121009:011101-172841	56229.28541	9.28541	WHIRCJ	19.27324	0.07101	195.3014	12.7551
CSS121009:011101-172841	56234.22657	14.22657	WHIRCH	18.53778	0.04162	384.4939	14.7330
CSS121114:090202+101800	56254.50847	2.50847	WHIRCH	18.08766	0.02963	582.0156	15.8819
CSS121114:090202+101800	56257.45088	5.45088	WHIRCH	18.29991	0.02746	478.6713	12.1028
CSS121114:090202+101800	56262.48385	10.48385	WHIRCH	18.39446	0.03869	438.7490	15.6268
CSS121114:090202+101800	56254.52481	2.52481	WHIRCJ	18.39741	0.02063	437.5576	8.3115

^a The WIYN+WHIRC K_s filter is called “WHIRCK” in SNooPy’s system transmission database. We adopt the SNooPy filter names here for future convenience.

^b Fluxes are given with respect to a zeropoint of 25: $\text{mag} = -2.5 \log_{10}(\text{flux}) + 25$.
(This table is a stub to show the structure. See the online version for the full table.)

Table 9. SweetSpot DR1 Summary

Category	Total	J	H	K_s
Total Open-Shutter Time [s]	743091			
Total Sky Target Open-Shutter Time [s]	707467	391913	289382	25214
Total Science Frames	14356	5553	7509	1080
Total Science Frames that are Standard Stars	2220	720	813	687
Fields Observed ^a	80	75	80	15
2MASS Stars Observed	786	705	786	141
Supernovae Observed ^a	74	69	74	9
Supernovae Observed ≤ 20 day past B -max	63	59	63	7
Supernovae Observed 0–20 days past B -max	59	55	59	7
Supernovae Observed ≤ 0 day past B -max	10	10	10	3
Observations	710	291	326	93
Average # Observations/Observed Object	8.9	3.9	4.1	6.2
Observations of Supernovae	493	219	250	24
Average # Observations/Observed Supernovae	6.7	3.2	3.4	2.7
Median # Observations/Observed Supernovae	6.0	3.0	3.0	2.0
Supernova Lightcurves	33	30	33	4
Supernova Lightcurve Points	168	72	89	7
Supernova Lightcurve Average # Points/Observed Supernovae	5.1	2.4	2.7	1.8
Supernova Lightcurve Median # Points/Observed Supernovae	5.0	2.0	3.0	1.5
Supernovae Lightcurve Points ≤ 20 day past B -max	82	36	42	4
Supernovae Lightcurve Points 10–20 days past B -max	75	33	39	3
Supernovae Lightcurve Points ≤ 0 day past B -max	7	3	3	1

^aThe difference between “Fields Observed” and “Supernovae Observed” is the six standard Persson standard star fields that were observed.

Table 10. Image Information

Name	Set	Filter	Date ^a	approxMjd	approxPhase d	imageName
CSS121006:232854+085452	A	H	2012-10-28	56228	21	CSS121006:232854+085452_A_H_20121028.fits
CSS121006:232854+085452	A	H	2012-11-02	56233	26	CSS121006:232854+085452_A_H_20121102.fits
CSS121009:011101-172841	A	H	2012-10-28	56228	8	CSS121009:011101-172841_A_H_20121028.fits
CSS121009:011101-172841	A	H	2012-11-02	56233	13	CSS121009:011101-172841_A_H_20121102.fits
CSS121009:011101-172841	A	J	2012-10-28	56228	8	CSS121009:011101-172841_A_J_20121028.fits
CSS121009:011101-172841	A	J	2012-11-02	56233	13	CSS121009:011101-172841_A_J_20121102.fits
CSS121114:090202+101800	A	H	2012-11-22	56253	1	CSS121114:090202+101800_A_H_20121122.fits
CSS121114:090202+101800	A	H	2012-11-25	56256	4	CSS121114:090202+101800_A_H_20121125.fits
CSS121114:090202+101800	A	H	2012-11-30	56261	9	CSS121114:090202+101800_A_H_20121130.fits
CSS121114:090202+101800	A	J	2012-11-22	56253	1	CSS121114:090202+101800_A_J_20121122.fits

(This table is a stub to show the structure. See the online version for the full table.)

^aYYYY-MM-DD of local evening at KPNO (MST).